1958.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

TENTH ANNUAL REPORT

OF THE

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

FOR

YEAR 1957-58.

Presented pursuant to Statute; ordered to be printed, 1st October, 1958.

(*Cost of Paper:*—Preparation, not given; 850 copies; approximate cost of printing and publishing, £600.

Printed and Published for the GOVERNMENT of the COMMONWEALTH OF AUSTRALIA by
A. J. ARTHUR, Commonwealth Government Printer, Canberra.
(Printed in Australia.)

No. 52 [GROUP F].—F.6733/58.—PRICE 14s.

COMMONWEALTH MYCOLOGICAL INSTITUTE
3- JUN 1959

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Commonwealth Scientific and Industrial Research Organization.

TENTH ANNUAL REPORT FOR YEAR 1957-58.

I. INTRODUCTORY.

1. General.

The Commonwealth Scientific and Industrial Research Organization was established in 1949, when the Science and Industry Research Act 1949 was proclaimed. Under that Act the Organization took the place of the existing Council for Scientific and Industrial Research, which in turn in 1926 had taken the place of the former Institute for Science and Industry.

The powers and functions of the Organization include: the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries in the Commonwealth of Australia, or any territory of the Commonwealth of Australia, or in connexion with any matter referred to the Organization by the Minister; the training of research workers; the making of grants in aid of pure scientific research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; the collection and dissemination of information relating to scientific and technical matters; the publication of scientific and technical reports and periodicals; and acting as a means of liaison with other countries in matters of scientific research.

2. Executive.

During the year the Chairman, Sir Ian Clunies Ross, spent three months working with the Committee on Australian Universities under the chairmanship of Sir Keith Murray. Also during the year, the Chairman was appointed Deputy Chancellor of the University of Melbourne.

In January, 1958, the Chairman spent some weeks in India and Pakistan, at the invitation of the Governments of those countries, and attended the Forty-fifth Session of the Indian Science Congress at Madras.

At the request of the Minister, the Right Honorable R. G. Casey, Mr. A. W. Coles visited the United States of America in the early part of 1958 to study the potentialities for exploitation there of inventions arising from the Organization's research.

The term of office of Mr. H. J. Goodes ended on 18th May, 1958; Mr. Goodes had been a member of the Executive since 19th May, 1949.

3. Advisory Council.

The following members retired from the Advisory Council during the year:—

- Mr. D. Mackinnon.
- Mr. I. M. McLennan, B.E.E.
- Professor Sir Leslie H. Martin, C.B.E., Ph.D., F.A.A., F.R.S.
- Professor M. L. Oliphant, M.A., Ph.D., D.Sc., LL.D., F.A.A., F.R.S.

The following new members have been co-opted to the Council:—

- Mr. B. Meecham, O.B.E.
- Professor J. W. Roderick, M.A., Ph.D., M.Sc., F.A.A.
- Mr. W. Sloan.
- Mr. L. W. Weickhardt, M.Sc.

4. New Officers-in-charge.

Mr. E. R. Hoare, B.Sc., M.I.E.E., has been appointed Officer-in-charge of the Irrigation Research Station, Griffith, New South Wales. Mr. Hoare was formerly in charge of the Horticultural Engineering Department of the National Institute of Agricultural Engineering, United Kingdom. Prior to this, he was a research engineer and physicist with the General Post Office in the United Kingdom.

Dr. D. B. Williams, B.Sc.Agr., B.Com., Ph.D., has been appointed Officer-in-charge of the Agricultural Research Liaison Section. Dr. Williams was formerly Assistant Director of the Commonwealth Bureau of Agricultural Economics, has studied agricultural economics at the University of Illinois, United States of America, and was for a number of years Rural Economist at Roseworthy Agricultural College.

5. Honours and Awards.

The following officers of the Organization received honours and awards during the year:—

- Dr. I. W. Wark, Chief, Division of Industrial Chemistry: General President, Royal Australian Chemical Institute.
- Mr. Ian Langlands, Chief, Division of Building Research: Member of the Interim Council, Monash University.
- Dr. D. F. Martyn, F.R.S., Chief Officer-in-charge, Radio Research Laboratories: Medal of the Physical Society of London.
- Mr. R. Milton Moore, Assistant Chief, Division of Plant Industry: President, Australian Institute of Agricultural Science.
- Dr. K. L. Sutherland, Assistant Chief, Division of Industrial Chemistry: H. G. Smith Memorial Medal, Royal Australian Chemical Institute.
- Dr. A. W. Turner, Assistant Chief, Division of Animal Health and Production: Gilruth Award, Australian Veterinary Association.
- Dr. H. R. C. Pratt, Officer-in-charge, Chemical Engineering Section, Division of Industrial Chemistry: Doctor of Science, University of London.
- Mr. B. Y. Mills, Senior Principal Research Officer, Division of Radiophysics: Thomas Ranken Lyle Medal, Australian Academy of Science.
- Dr. J. M. Cowley, Senior Principal Research Officer, Division of Industrial Chemistry, and Mr. J. F. Wild, Principal Research Officer, Division of Radiophysics: Edgeworth David Medal, Royal Society of New South Wales.
- Dr. C. S. Piper, Senior Principal Research Officer, Division of Soils: Verco Medal, Royal Society of South Australia.
- Mr. A. Walsh, Senior Principal Research Officer, Division of Industrial Chemistry: Fellow, Australian Academy of Science.
- Dr. A. B. Wardrop, Senior Principal Research Officer, Division of Forest Products: Doctor of Science, University of Melbourne.
- Dr. J. A. Barker, Principal Research Officer, Division of Industrial Chemistry: Doctor of Science, University of Melbourne.
- Dr. M. A. Jermyn, Principal Research Officer, Wool Textile Research Laboratory, Parkville: Grimwade Prize, University of Melbourne.
- Dr. N. King, Principal Research Officer, Dairy Research Section: Silver Medal, Australian Society of Dairy Technology.
- Mr. I. E. Newnham, Principal Research Officer, Division of Industrial Chemistry: Waverley Gold Medal of the scientific journal, *Research*.

Dr. J. M. Thomson, Principal Research Officer, Division of Fisheries and Oceanography: Doctor of Science, University of Western Australia.

Dr. W. O. Williamson, Principal Research Officer, Division of Industrial Chemistry: Doctor of Science, University of London.

Mr. C. S. Andrew, Senior Research Officer, Division of Plant Industry: Rockefeller Fellowship.

Mr. J. E. Coaldrake, Senior Research Officer, Division of Plant Industry: Commonwealth Fund Fellowship.

Dr. L. W. Davies, Senior Research Officer, Division of Radiophysics: Commonwealth Fund Fellowship.

Dr. D. S. Mathewson, Research Officer, Division of Radiophysics: Leverhulme Research Fellowship, University of Manchester.

Dr. J. H. Bradbury, Research Officer, Wool Textile Research Laboratory, Geelong: Rennie Memorial Medal, Royal Australian Chemical Institute.

6. FODDER CONSERVATION SECTION.

The name of the former Plant Fibre Section at Highett, Victoria, has been changed to Fodder Conservation Section. The Section is studying the problems associated with haymaking and ensilage.

7. RETIREMENT OF SIR JOHN MADSEN AS CHAIRMAN OF THE RADIO RESEARCH BOARD.

Emeritus Professor Sir John Madsen, B.E., D.Sc., F.A.A., retired as Chairman of the Radio Research Board during the early part of 1958. It was largely due to the efforts of Sir John Madsen that the Board was formed in 1927 to initiate and develop radio research in Australia, and Sir John has been its Chairman continuously since its formation. Under Sir John's guidance the Board has enabled many outstanding students to pursue post-graduate studies, and has led Australian scientists to play a leading role in research on the ionosphere and radio propagation. The policy of the Board has had a very marked practical influence on the progress of radio communication in Australia and throughout the world. Sir John has had a long association with the Organization and its predecessor the Council for Scientific and Industrial Research, having been at various times a member of the Advisory Council, a member of the New South Wales State Committee and Chairman of the Electrical Research Board. He is succeeded as Chairman of the Radio Research Board by Professor L. G. H. Huxley, M.A., D.Phil., F.A.A., Professor of Physics, University of Adelaide.

8. ADVISORY COUNCIL COMMITTEE ON THE NATIONAL STANDARDS LABORATORY.

At the request of the Advisory Council, a committee was convened to consider the future development of the National Standards Laboratory. The committee represented both science and manufacturing industry and included—

Dr. A. V. Astin, Director of the National Bureau of Standards, United States of America.

Mr. J. W. Harrod, Deputy Chief Engineer, Electricity Trust of South Australia.

Captain G. I. D. Hutcheson, Managing Director, Cockatoo Docks and Engineering Co. Pty. Ltd.

Sir John Madsen, Emeritus Professor of Electrical Engineering, University of Sydney.

Professor M. L. Oliphant, F.R.S., Director, Research School of Physical Sciences, Australian National University.

Mr. W. W. Pettingell, General Manager, Australian Gas Light Co.

Mr. H. B. Somerset, Managing Director, Associated Pulp and Paper Mills.

Mr. H. A. Wills, Department of Supply.

Dr. F. W. G. White, Deputy Chairman, C.S.I.R.O.

Dr. S. H. Bastow, Chief Executive Officer, C.S.I.R.O.

Mr. L. Lewis, Officer-in-charge, C.S.I.R.O. Industrial Research Liaison Section.

The Committee met in November 1957 and submitted a report to the Advisory Council (see Chapter XXII., Section (b)).

As one of the first consequences of the recommendations of the Advisory Council Committee on the National Standards Laboratory, Mr. N. A. Esserman, B.Sc., F.Inst.P., A.M.I.E. (Aust.), has been appointed as the first Director of the National Standards Laboratory. Mr. Esserman will continue as Chief of the Division of Metrology.

9. COLLABORATION WITH THE UNIVERSITIES.

Many of the Divisions and Sections have close ties with the universities, and work undertaken in co-operation in this way is described in the appropriate sections of this report. A number of new arrangements have been made with the universities during the year, included amongst which are the following:—

The Organization is co-operating with the Australian National University in the development of a Biological Inorganic Chemistry Unit. This group is preparing complex chemicals which are of great importance in biological research in many laboratories throughout Australia.

The Fodder Conservation Section has become closely associated with the School of Agriculture at the University of Melbourne especially on the biochemical aspects of its work. The Reader in Agricultural Biochemistry in the School has been appointed as a scientific adviser to the Section.

The Organization has assisted the University of Adelaide with the maintenance of an electron microscope which has been used by its Animal Genetics Section. At the University of Sydney, a joint C.S.I.R.O.-University electron microscope laboratory is being established. It will be equipped with two instruments and will have a staff of four. The cost of establishing and running this unit is to be shared equally between the University and the Organization.

Support has also been given to the following new projects:—

The establishment of a Readership in Dairy Husbandry at the University of Sydney and work on the action of rennet in casein; studies on the interaction of the endoplasmic reticulum of plant cells with other cellular components at the University of Adelaide; and research into the microbiology of soil in rice fields at the University of Queensland.

The Division of Fisheries and Oceanography again organized a School of Marine Biology which was attended by students from the Universities of Sydney, Adelaide, Melbourne, and New England.

C.S.I.R.O. officers have continued to lecture on special topics to students in nearly all the Australian universities. An arrangement has recently been made whereby students for higher degrees at the National University may work in C.S.I.R.O. laboratories under the supervision of a C.S.I.R.O. officer, thereby having access to the Organization's special equipment.

10. CO-OPERATIVE INDUSTRIAL RESEARCH.

The Organization encourages industrial establishments to join with it in co-operative research projects and programmes. Industry can enlist the collaboration of the Organization's research resources in activities ranging from single sponsored research projects to autonomous research associations.

The report of the work of the Industrial Research Liaison Section, established to strengthen the liaison between the Organization and secondary industry, is described in Chapter XXXI., Section 4.

The Organization has continued its financial support to the Australian Leather Research Association, the Bread Research Institute of Australia, the Wine Research Institute, and the Australian Coal Association (Research) Ltd.

A number of new sponsored research projects with industry have been initiated during the year. These include:

Work on the sintering of brown coal ash by the Division of Industrial Chemistry is being supported by the State Electricity Commission of Victoria, the Gas and Fuel Corporation of Victoria, and Australian Paper Manufacturers Ltd.; and assessment of a process for the production of rutile from ilmenite is being made by the Division of Industrial Chemistry for a group of Australian Companies; the Division of Building Research is investigating the practicability of using ordinary household hot-water heaters fired by brown coal briquettes for space heating as well as water heating in lower and medium priced houses for the State Electricity Commission of Victoria; a full examination was made by the Ore-Dressing Laboratory, Melbourne, of proposals for expanding production at Wattle Gully Gold Mines N.L.

The above co-operative research projects are additional to those mentioned in previous Annual Reports. A full list of contributions and donations for research received by the Organization is given in Chapter XXXV., Section 2.

11. CONFERENCES ON FOREST PRODUCTS RESEARCH.

The Organization co-operated in arranging the first conference in Australia of representatives of British Commonwealth Forest Products Research Laboratories which met in August, 1957. This was possible because Australia and New Zealand were the host countries for the Seventh British Commonwealth Forestry Conference, and some of the delegates attending the Forestry Conference were able first to confer at the Forest Products Research Conference. The conference was opened by the Minister, the Right Honorable R. G. Casey, and the discussions were mainly on fundamental research and the organization of research. The delegates were given a résumé of research in this field being carried out in Australia, with particular reference to the increasing co-ordination between Australia and New Zealand in forest products research.

Amongst the overseas scientists who attended the conferences were: Colonel J. H. Jenkins, Chief, Forest Products Laboratories of Canada; Professor R. W. Wellwood, University of British Columbia; Dr. F. Y. Henderson, Director, Forest Products Research Laboratory, United Kingdom; Mr. J. H. Van Wyk, Chief Research Officer, Forest Products Institute, South Africa; Mr. J. J. Byrne, Director, Division of Forest Products Research, United States Forest Service; and Mr. J. S. Reid and Mr. H. R. Orman, New Zealand Forest Service.

12. OVERSEAS VISITS, FELLOWSHIPS, AND STUDENTSHIPS.

Officers of the Organization represented Australia at a number of overseas scientific conferences during the year. These included the Fourteenth International Congress of Pure and Applied Chemistry, the Twelfth General Assembly of the International Union of Scientific Radio, the Sixth Commonwealth Congress on Mining and Metallurgy, the Fifteenth International Congress on Zoology, the Ninth Pacific Science Congress, the Nineteenth Conference of the International Union of Pure and Applied Chemistry, the General Assembly of the International Union of Geodesy and Geophysics, the Fourth F.A.O. Wood Technology Conference, the Pan Indian Ocean Science Association Congress, and the International Genetics Congress.

Seven officers went overseas for short periods as advisers on F.A.O. assignments, at the invitation of U.N.E.S.C.O., under the Colombo Plan, or at the invitation of overseas governments.

The Chief of the Division of Forest Products, Mr. S. A. Clarke, visited the United Kingdom at the request of the Department of Scientific and Industrial Research to advise on problems related to the pulping of plantation thinnings.

The Chief of the Division of Food Preservation and Transport, Dr. J. R. Vickery, spent five months in the United Kingdom at the invitation of the Ministry of Agriculture, Fisheries, and Food to examine and report on proposals for the extension of research on meat in the United Kingdom.

A number of officers made overseas visits to collect information on new developments in scientific research and to acquire general experience in their particular fields. In addition, four officers went abroad at the invitation of overseas universities and other research organizations for consultations concerning special aspects of their work.

Six Australian graduates were given studentships to enable them to undertake advanced research training overseas, and in addition, four officers of the organization were awarded overseas studentships for the same purpose. Two officers were awarded traineeships for advanced overseas training in specific fields of research.

In addition, 75 graduates were awarded studentships to continue their post-graduate studies towards higher degrees at Australian universities, 26 of them gaining senior studentships, the tenure of which is for two years, and 49 of them gaining junior studentships, for one year only. One of these students came from England while another was a New Zealand graduate. One officer of the Organization was awarded a Divisional studentship for advanced study at an Australian university.

The Organization continued to provide training facilities for students and Fellows coming to Australia under the auspices of the Colombo Plan, F.A.O., and U.N.E.S.C.O.

13. GIANT RADIO TELESCOPE.

The design study for the proposed giant radio telescope referred to in the Ninth Annual Report to be erected for the Division of Radiophysics is now complete, and the decision has been taken to proceed with the construction of the instrument. A site for the telescope has been selected near Parkes, New South Wales (see Chapter XXVIII., Section 3).

14. APPLICATION OF THE RESULTS OF WOOL TEXTILE RESEARCH.

In Chapter XVI., reference is made to important advances resulting from research aimed at improving the methods employed in the manufacture of wool textiles. In attempting to ensure that the results of its wool textile research are fully exploited, the Organization faces problems more complex than those that normally arise in applying its work in other fields. The essential objective of wool textile research by C.S.I.R.O. is to enhance the position of wool as a textile fibre. Since the great bulk of the Australian wool clip is processed overseas, new developments arising from research, if they are to be effective, must be applied not only in Australia but in the major wool consuming countries of the world.

The obvious first step is to apply advances in technology in the Australian textile industry. Once their advantages have been demonstrated in this way adoption of the new techniques in other countries would appear to be likely. But in a traditional industry widespread adoption of innovations is apt to be very slow, and unless technical assistance can be given to users there is a real danger of new developments being discredited because of faulty application.

For prompt and effective transfer of research results to the wool textile industries of overseas countries, assistance from adequate technical liaison groups in those countries is considered to be essential. Except in relatively rare instances C.S.I.R.O. cannot divert staff for technical liaison duties overseas, and moreover this type of technical liaison work can best be carried out in association with promotional activities that are not appropriate for C.S.I.R.O. It seems, therefore, that if C.S.I.R.O. research in the wool textile field is to be applied to best advantage overseas it must be through the agency of technical liaison teams associated with a promotional organization active throughout the world.

As a result of representations made by the Australian Wool Bureau some extension of the technical liaison activities of the International Wool Secretariat and its affiliated organizations has recently been agreed upon. In this connexion, the Australian Wool Bureau and the International Wool Secretariat are co-operating in making known to clothing manufacturers throughout the world the Organization's SI-RO-SET process for the permanent pleating and creasing of garments. C.S.I.R.O. would like to see a major expansion of this type of work by the International Wool Secretariat and its associates, with full acceptance by those bodies of responsibility for promotion of new technical developments in the wool textile industry.

15. Cobalt Pellets.

Graziers in Australia have widely adopted the heavy pellet invention developed within the Division of Biochemistry and General Nutrition for administering cobalt supplements to sheep (see Chapter VII., Section 7). These pellets lodge in the forestomachs of the sheep and give up the small quantity of cobalt required for the animal's healthy development.

Applications for patents covering the invention have been lodged in a number of countries overseas. Six Australian companies are manufacturing cobalt pellets under licence and have been permitted to use the trade mark SI-RO-CO to distinguish pellets conforming to the Organization's requirements. One of these firms has been granted an exclusive licence to use the invention overseas, and it is expected that substantial royalty payments will accrue to the Organization.

16. Improved Pastures in Queensland.

A considerable programme of research centred on the Organization's Plant and Soils Laboratory, Brisbane, is concerned with improving the quality and quantity of fodder available to grazing animals in Australia's northern areas. Most of the research has so far been concerned with the vast area of Queensland that lies south of the Tropic of Capricorn and which receives good rainfall—an area of some 100,000 square miles. It is already clear that it will be possible to greatly increase the carrying capacity of this region through the replacement of natural pastures by sown pastures.

The soils in this area are almost universally short of nitrogen, and accordingly a great deal of work has been concerned with legumes which are being introduced, along with new grasses, into experimental plots of pasture. Several promising species are under test in the field, and it is expected that some important defects which have now been defined will be eliminated by breeding and selection.

It has already been established that many preconceived ideas derived from experiences in southern Australia are not applicable in the north. New information being obtained in the area will have relevance in northern Australia generally, and in many other tropical and subtropical regions throughout the world.

Although this work will be of significant interest to all graziers, it will be of greatest value to the beef cattle industry.

17. Overseas Visitors.

Australian scientists received advice and stimulation from leading scientists from overseas who visited Australia during the year. The Organization particularly welcomed the following visitors:—

Sir Harry Jephcott, Chairman of the Council of the the Department of Scientific and Industrial Research, United Kingdom; Professor E. N. da C. Andrade, F.R.S., Emeritus Professor of Physics, University of London; Dr. A. V. Astin, Director of the National Bureau of Standards, United States of America; and Professor J. H. Gaddum, F.R.S., Department of Materia Medica, University of Edinburgh.

Other scientists from overseas establishments who visited the Organization during the year, or who actively co-operated on research projects, included—

Professor T. A. Geissman, Professor of Chemistry, University of California; at the Division of Industrial Chemistry, studying stock poison plants.

Dr. James N. Luthin, Associate Professor of Irrigation, University of California; at the Division of Soils studying irrigation and soil physics.

Dr. Donald F. Poulson, Professor of Zoology, Yale University; at the Division of Entomology studying the digestion of insects.

Dr. R. B. Montgomery, Associate Professor of Oceanography, Johns Hopkins University; at the Division of Meteorological Physics studying descriptive physical oceanography.

Professor Lee Moon Kang of the Chenbuk National University, Korea; at the Division of Industrial Chemistry studying flotation.

Professor G. F. Stewart, Chairman of the Department of Poultry Husbandry, University of California; at the Division of Food Preservation and Transport.

Dr. J. Dainty, Reader in Biophysics, University of Edinburgh; at the Division of Biochemistry and General Nutrition.

Dr. Gabriel Harmoir, Agrégé et Chef de Travail, Laboratoire de Biologie Générale, University of Liège, Belgium; at the Division of Food Preservation and Transport.

Dr. E. J. L. Soulsby, of the School of Veterinary Medicine, University of Cambridge; at the McMaster Animal Health Laboratory studying immunity to nematode parasites.

Professor M. S. Doty, Department of Botany, University of Hawaii; at the Division of Fisheries and Oceanography comparing methods of assessing biological productivity of the sea.

In addition, a number of scientists from overseas have visited the Organization as delegates to conferences and symposia, under the Colombo Plan and various training schemes.

18. Science and Industry Endowment Fund.

The Executive, as Trustees of the Science and Industry Endowment Fund, awarded grants to assist research workers as follows:—Mr. N. V. Dobrotworsky to work on the ecology and taxonomy of mosquitoes; Dr. J. Pearson to continue his work on Australian marsupials; Dr. J. W. Evans to enable him to visit New Caledonia to collect material for a monograph on the Homoptera group of insects; Mr. Tarlton Rayment to enable him to complete the catalogue of the Apoidea of Western Australia; and Mr. J. Warham for ornithological work.

In addition, small sums were contributed towards travelling expenses, as follows:—Dr. M. H. Maguire of the New South Wales University of Technology who received a visiting Fellowship at the Sloan-Kettering Institute for Cancer Research; Mr. J. A. Aird of the State Rivers and Water Supply Commission of Victoria to attend the annual Conference of " Aslib " in London; and Mr. D. P. Fielder, a student of the University of Adelaide, to attend the School of Marine Biology at the Division of Fisheries and Oceanography, Sydney. Grants were also made to three overseas scientists to defray expenses associated with visits to Australia. The recipients were: Professors J. M. Robertson, F.R.S., Dr. J. F. Loutit, and Dr. L. H. Gray.

A grant was made to the Science Teachers' Association of Victoria as a general contribution to its work.

19. BUILDINGS AND ACCOMMODATION.

There is reason for concern at the standard of buildings and accommodation in which the Organization's staff are working in some of the Divisions and Sections. This situation has steadily deteriorated in the post-war years, and the annual construction of new buildings has been inadequate to keep pace with the growth which has taken place in the Organization's activities and staff. This is a serious matter. Research scientists are in keen demand all over the world, and it must be recognized that the provision of accommodation and equipment of high standard is one of the most potent factors in retaining men of high ability in this country.

During the year, the following buildings were completed:—

- New South Wales—
  - Camden—Three rooms at "Harben Vale", Radio Research Laboratories.
  - Griffith—Additions to residence of Officer-in-charge, Irrigation Research Stations.
  - Ryde—Library extension, Wool Textile Research Laboratories.
- Victoria—
  - Highett—Workshop building, Engineering Section.
  - Parkville—Chemical store, Wool Textile Research Laboratories.
- Australian Capital Territory—
  - Canberra—Laboratory building, Division of Plant Industry.
    - Service building, Division of Land Research and Regional Survey.
    - Garage extension.
- Queensland—
  - Mareeba—Laboratory and four residences, Tobacco Research Institute.

The following buildings were acquired:—

- New South Wales—
  - Deniliquin—Two residences.
- Victoria—
  - Parkville—"Mayfair", Royal-parade, Parkville, Wool Textile Research Laboratories.

The following are in course of construction:—

- New South Wales—
  - Cronulla—Laboratory extension, Division of Fisheries and Oceanography.
  - Prospect—Main building, Division of Animal Health and Production.
  - Ryde—Laboratory building and workshop, Coal Research Section.
- Victoria—
  - East Melbourne—Additional story at Head Office.
  - Geelong—Extension to weaving shed, Wool Textile Research Laboratories.
- Queensland—
  - St. Lucia—Main building, Plant and Soils Laboratory.
- South Australia—
  - Adelaide—Main building, Division of Soils.

20. FINANCE.

Chapter XXXV. gives details of the expenditure of £7,414,261 incurred during 1957-58 by the Organization from all funds at its disposal. Of this sum, £6,861,278 was expended in connexion with normal research activities, £429,328 on capital works, and £123,655 on grants to outside bodies. The funds for this expenditure were derived from the Commonwealth Treasury, contributions made available from outside bodies including the Wool Research Trust Fund Trust Account, and the Organization's revenue from miscellaneous sources.

The following table summarizes the sources of these funds, and activities on which they were expended. Details of the expenditure may be ascertained by reference to the relevant Sections of Chapter XXXV.

Source of Funds.	Investigations.	Capital Works.	Grants to Outside Bodies.	Total.
	£	£	£	£
Treasury Appropriation	5,427,102 (Section 1)	89,636 (Section 5)	123,655 (Section 6)	5,640,393
C.S.I.R.O. Revenue	152,501 (Section 4)	..	..	152,501
Total Treasury Funds	5,579,603	89,636	123,655	5,792,894
Wool Research Trust Fund Trust Account	998,507 (Section 3)	269,421 (Section 3)	..	1,267,928
Contributions (other than wool) ..	283,168 (Section 2)	70,271 (Section 2)	..	353,439
	6,861,278	429,328	123,655	7,414,261

The Organization is gratified by the way in which various bodies continue to support it, and by the marked interest shown by certain sections of industry which have provided funds for co-operative research. Among the many contributions received, reference may be made to those of the Australian Meat Board, the Australian Dairy Produce Board, the Australian Egg Board, the Queensland Meat Industry Board, the New South Wales Department of Agriculture, the New South Wales Water Conservation and Irrigation Commission, the Metropolitan Meat Industry Board of New South Wales, the Ian McMaster Bequest, the Alexander Fraser Memorial Fund, the Burdekin Bequest, the dried fruits industry, the Australian Institute of Mining and Metallurgy, the State Electricity Commission of Victoria, the Cement and Concrete Association of Australia, the timber industry, the Associated Fibrous Plaster Manufacturers of Australia, the Paint Manufacturers' Association, Bowen Consolidated Coal Mines Ltd., and the United Graziers' Association of Queensland.

21. ORGANIZATION.

For the purpose of carrying out its research work, the Organization has established a number of Divisions and Sections. The Divisions, of which there are now eighteen, comprise the major establishments, which may be further subdivided into Sections; there are also eighteen independent Sections comprising establishments which have not reached a stage of development, so far as the scope and magnitude of their operations are concerned, to justify their designation as Divisions.

In the present report, an attempt has been made to group the material according to its subject matter rather than according to the Divisions or Sections concerned. Additional chapters and appropriate cross-references have been inserted, however, to permit the work of any particular Division to be reviewed as a whole.

As the Organization's investigations extend on a Commonwealth-wide basis and as many of the investigations which are being conducted—particularly those concerned with problems affecting the agricultural and pastoral industries—necessitate experimental work in the field, a number of branch laboratories and field stations have been established in various parts of Australia.

The Head Office of the Organization is in Melbourne and associated with it are the Organization's central library, Agricultural Research Liaison Section, Industrial Research

Liaison Section, Films Unit, and Editorial, Publications, and Translation groups. The Organization also maintains Australian Scientific Liaison Offices in London and Washington.

The Divisions which have been established (in order of their formation) are as follows:—

- *Plant Industry*, with head-quarters in Canberra and main laboratories in Canberra and Brisbane, regional laboratories in Perth, Hobart, and Deniliquin, New South Wales, and field stations, experimental farms, &c., at Canberra, at Lawes, Applethorpe, and Mareeba, Queensland, at Trangie, New South Wales, and at Kojonup, Western Australia.
- *Entomology*, with head-quarters and main laboratories in Canberra, a smaller laboratory in Sydney, and field stations at Trangie, New South Wales, at Rockhampton, Queensland, and at Perth.
- *Animal Health and Production*, with head-quarters in Melbourne, laboratories in Melbourne, Sydney, Prospect (New South Wales), and Brisbane, and field stations at Armidale and Badgery's Creek, New South Wales, at Cunnamulla, Amberley, and Rockhampton, Queensland, and at Werribee and Tooradin, Victoria.
- *Biochemistry and General Nutrition*, with head-quarters in Adelaide and field stations at O'Halloran Hill, Robe, and Brecon, South Australia.
- *Soils*, with head-quarters and laboratories in Adelaide, and branch laboratories in Perth, Canberra, Brisbane, Melbourne, and Hobart.
- *Forest Products*, Melbourne.
- *Food Preservation and Transport*, with head-quarters and laboratories in Sydney, branch laboratories in Brisbane and Hobart, and minor laboratories in Gosford, New South Wales.
- *Fisheries and Oceanography*, with head-quarters and main laboratories in Cronulla, New South Wales, laboratories in Perth and Melbourne, and field stations at Hobart and Thursday Island.
- *Metrology*, *Physics*, and *Electrotechnology*, comprising together the National Standards Laboratory, Sydney.
- *Radiophysics*, Sydney.
- *Industrial Chemistry*, with head-quarters and main laboratories in Melbourne, and branch laboratories in Sydney, Adelaide, and Perth.
- *Tribophysics*, Melbourne.
- *Building Research*, Melbourne.
- *Mathematical Statistics*, Adelaide.
- *Meteorological Physics*, Melbourne.
- *Land Research and Regional Survey*, with head-quarters in Canberra, and field stations at Alice Springs and Katherine, Northern Territory, and in the Kimberley region, Western Australia.

The following are the Sections:—

- *Irrigation Research Stations*, at Merbein, Victoria (Murray Irrigation Areas), and Griffith, New South Wales (Murrumbidgee Irrigation Areas).
- *Radio Research Laboratories*, with head-quarters in Camden, New South Wales, and a laboratory in Sydney.
- *Fodder Conservation*, Melbourne.
- *Ore-dressing Investigations*, Melbourne, and Kalgoorlie, Western Australia.
- *Mineragraphic Investigations*, Melbourne.
- *Dairy Research*, Melbourne.
- *Coal Research*, Sydney.
- *Physical Metallurgy*, Melbourne.
- *Wildlife Survey*, with head-quarters in Canberra and field stations at Perth, and Albury, New South Wales.
- *Mathematical Instruments*, Sydney.
- *Wool Textile Research Laboratories*, in Melbourne, Sydney, and Geelong, Victoria.
- *Agricultural Research Liaison*, Melbourne.
- *Engineering*, Melbourne.
- *Industrial Research Liaison*, Melbourne.

In addition, regional centres (co-operative research units staffed with officers from the appropriate specialist Divisions to attack the problems of a particular region) have been established as follows:—

- *Tasmanian Regional Laboratory*, Hobart.
- *Western Australian Regional Laboratory*, Perth.

II.—SOILS.

1. GENERAL.

As scientific knowledge and understanding of fertility progresses, the biological processes within the soil appear to increase in their complexity. Agricultural, pastoral, and silvicultural industries all depend on the maintenance of soil fertility. The efficient development and use of Australia's land resources must be based on a fundamental knowledge of soils, and their characteristics and distribution.

The Organization's research in this field is undertaken by the Division of Soils with head-quarters at the University of Adelaide. Work on soils with special reference to their behaviour under irrigation is undertaken at the Commonwealth Research Station (Murray Irrigation Areas), Merbein, Victoria, and at the Irrigation Research Station (Murrumbidgee Irrigation Areas), Griffith, New South Wales (see Chapter IV., Sections 2 and 3), and at the Regional Pastoral Laboratory, Deniliquin, New South Wales (see Chapter III., Section 17).

Division of Soils.—Some internal re-organization of the Division has taken place during the year. Requirements for study in soil microscopy have been so demanding that it has been decided to develop a new Section in this field of research.

The Soil Mechanics Section has continued to widen its interests, especially in foundation problems in building, pavement engineering, and soil stabilization. Its growth and contacts, especially in Melbourne, and the need for associated administration there have led to a decision to give it status as an independent Section as from 1st July, 1958.

Progress is being made with the new building for the head-quarters of the Division. Completion of the first laboratory and ancillary building is expected in a few months.

Morphological and chemical data are being compiled for three representative profiles of each of the great soil groups which have been recognized in Australia.

2. SOIL SURVEY AND PEDOLOGY.

(Division of Soils.)

In the brigalow areas in Queensland the occurrence of unusual soil features such as acid subsoils below neutral and alkaline surface and subsurface soils has been encountered on a widespread basis. This quite unexpected feature is associated with shrinking and swelling montmorillonite clays and salinity rising with depth in the soil profile. The problem is being pursued along with soil classification and mapping studies in the area.

In Tasmania the origin of widespread sandy soils especially through the centre of the State has been resolved by careful studies of the nature and distribution of the sands and the soils developed thereon. These are thought to be periglacial materials brought down by the rivers in Pleistocene times and redistributed by aeolian action as sheets of sand over the surrounding country. These soils vary greatly in depth and they blanket country of quite variable relief.

Atlas of Australian Soils.—The results of preliminary studies were presented to a conference of regional officers in September, 1957, when it became clear that an atlas of Australian soils involving several map sheets at relatively small scale was the more satisfactory approach.

Soil Classification.—A technical memorandum setting out an approach to the morphological classification of soils in factual terms was prepared for circulation within the Division during 1957. The response to the method was generally favorable so that it is now possible to extend this approach to develop a key for coding described soil profiles. The preparation of this key has proceeded almost to the stage where it could be circulated more generally.

The projects concerning the atlas of Australian soils and soil classification have many common points of interest at the practical level, but, because the former is concerned with the distribution of soils while the latter aims to classify soils, research in the early stages must be made separately to avoid confusion between the two subjects.

(*a*) *Western Australia.*—The emphasis during the year has continued to be on the study of the principles of soil distribution. In addition, however, the relationships thus established between the soils and the age and nature of the erosional and depositional surfaces on which they occur has made possible the rapid compilation of soil association maps covering almost 3,000 square miles.

The field work for a pedological study of the soils of the Swan Coastal Plain is now complete. The soil pattern of the area has been shown to be controlled by the distribution of a number of depositional systems, both aeolian and alluvial. This knowledge of the soil systems has enabled a soil association map of the Coastal Plain from Perth to Busselton, a total of some 2,500 square miles, to be produced in a very short time.

At York further progress has been made with the study of Tertiary and younger laterite surfaces and the soils associated with them. The lateritic soils occur at a number of levels in the landscape, including the valley floors, where they may be found either as surface exposures, or as extremely weathered acid layers buried under younger, fine-textured, calcareous soils. As a result of investigations of this sort 300 square miles have been surveyed at the soil association level.

The work at Merredin has continued with particular emphasis on the nature of the depositional layers of the valleys of the wheat belt. With the co-operation of the Western Australian Department of Agriculture, several bores were put down to 30 feet, and revealed the presence of a number of layers of varying texture, structure, calcareousness, and permeability. Since these layers provide the aquifers for the watertables of the valleys, and extend up into the catchment areas, an understanding of them will be an important contribution to the problem of salt encroachment and rising water-tables in the valley floors. In addition, some 150 square miles of country have been surveyed in soil associations.

(*b*) *South Australia.*—Operations in this State have been much reduced by transfer of officers to other centres or to other projects, but a fair volume of information from earlier completed work is on the way to publication. The time between completion of field work and publication of results is still embarrassingly long in most cases, owing particularly to shortage of drawing office staff rather than to the earlier delays in completion of soil analyses.

Apart from the small-scale mapping of the soils of South Australia, referred to above, the main mapping projects have been in the south-east part of the State. The other field work has been confined to three smaller areas.

In the south-east a reconnaissance survey of Counties Robe and MacDonnell is half complete; it will carry on northward from a similar survey of County Grey. The soil association mapping around Lakes Alexandrina and Albert led on to studies of the ancient advance and retreat of the sea and the lakes in this area, as shown by landscape features and soils data.

At Elizabeth, the new township 15 miles north of Adelaide, the survey work in connexion with building problems is now completed. However, studies are still continuing there of the soil formations which may be typical of the Adelaide plains. Considerable interest is attached to the development of a power-driven core sampler, initially for use in the Elizabeth survey, which can take a monolith to a depth of 12 feet.

Detailed mapping of soils at the Mount Crawford Forest Reserve was abandoned through shortage of staff, after nearly half of its pine plantation had been inspected. Subsequently a simplified mapping procedure was used to cover much of the remainder and to relate the soils to those previously examined in areas nearby.

(*c*) *South-eastern Region.*—During the year three large projects depending on field work have been brought to a conclusion. They have demonstrated the feasibility of studying soils as components of *ground surfaces* having stratigraphical relationships. These studies enable the phase of soil development in South-eastern Australia to be outlined.

Further detailed work in lower Murrakool has been completed. A resurvey of the soils of the Worrinen area has been made.

A soil reconnaissance of some 3,000 square miles of wheat growing country around Wagga has been completed. Detailed soil and landscape studies show that the soils are developed on two layers of parna and on two hillwash sheets.

In co-operation with New South Wales State bodies the Division participated in a detailed study of the soils of the Wagga Research Farm.

Study was completed of soil layering on the river terraces in the intramontane basins and on the adjoining hillslopes around Canberra.

Reconnaissance work of the forest soils in conjunction with officers of the Commonwealth Forestry and Timber Bureau is continuing. During the course of one of the forestry surveys a Colombo Plan fellow from Burma was trained in soil survey methods to the point which enabled him to complete successfully a survey of some 1,200 acres involving associated cartographical and collation work.

A study of seepage areas in the Canberra area was carried out at the request of the Bureau of Mineral Resources, Canberra.

A soil survey of the C.S.I.R.O. Experimental Farm, Ginninderra, comprising approximately 2,200 acres, was completed.

A reconnaissance survey of the Yass River Catchment area is in progress, and preliminary results have been presented at various meetings of the Southern Tablelands planning committee.

Near Nowra on the south coast of New South Wales more detailed studies of hillslope soil layers, river terraces, and landslide materials have been made. The soil pattern is a complex of old and young layers and the persistence of the older ones depends on the history of erosion and deposition.

The Badgery's Creek soil survey for infiltration experiments has been completed.

As a result of co-operation with the University of Sydney, a general soils reconnaissance is being made on part of the University Experiment Stations, "Corstorphine" and "Mayfarm". These stations are in the vicinity of Camden.

(*d*) *Queensland Region.*—A reconnaissance survey of 400 square miles of land in the Brisbane-Beenleigh area has been completed and samples of representative profiles are being studied in the laboratory. Generally the soils are of low fertility, and intensive cropping has largely been limited to the friable red soils—red earths and krasnozems—which have excellent physical properties but require heavy fertilization for high yields. Agricultural development is gradually extending to accessible areas of the podzolic soils that dominate the area. The productivity of important areas of partly developed soils—especially the gleys of the coastal plains and some podzolic soils—could undoubtedly be increased greatly by good management including heavy fertilization.

The soils of the Tobacco Research Institute, Mareeba, have been defined and mapped in great detail as a basis for the siting and interpretation of field experiments. Most have formed from an extensive area of old alluvium, and differences of topography and drainage are the main factors determining the types. Contiguous occurrences of well-drained friable red earths form the most useful area for experimental studies.

An extensive survey is being made of the soils of the brigalow (*Acacia harpophylla*) lands of Queensland to give perspective to more detailed studies to follow. Earlier work revealed the widespread occurrence of extremely acid clays of low nutrient status at shallow depth. The relationship of these clays to overlying calcareous soil horizons and underlying materials is being studied by deep borings in the Tara district. Recent examinations have shown that some alkaline sedentary soils overlying calcareous rocks in the Wandoan area also have acid reaction in their subsoils and weather parent materials.

A start has been made on soil studies in the Central Burnett region. Remnants of surfaces of different ages are apparent and may provide evidence of the pedological history of the area. In addition knowledge of the character and distribution of the soils should prove useful in extending the findings of research at " Brian Pastures " Pasture Research Station.

(*e*) *Tasmanian Region*.—The regional survey is being continued and two more sheets of the series " Reconnaissance Soil Map of Tasmania ", at scale 1 inch to 1 mile have been issued this year, one of an area of 450 square miles and the other of 380 square miles, to bring the total covered by this series of maps to date to 2,900 square miles. Recently several expressions of appreciation of the value of these maps have been received from authorities concerned with land use. Two further units of the survey, each of 450 square miles, are in hand and are expected to be completed shortly. Each of these represents a co-ordination and extension of earlier work, one in the Launceston Tertiary Basin and the other in the lower Derwent Valley.

Arising from a report of a Parliamentary Select Committee, an investigation is being made of the soils of some 20,000 acres near Marrawah on the west coast, at present in use as a cattle agistment area. Much of this has shallow stony soils on which only limited further development seems practicable, but the country nearer the coast has deeper soils on a succession of sheets of sand blown inland from the coast. The older of these sheets are stable and seem promising for establishment of sown pasture.

(*f*) *Arid Region—Alice Springs*.—Soil survey work of a broad-scale type has progressed in the Ringwood, Todd River, and Rodinga areas east and south of Alice Springs. More detailed work on areas near the town designed to assist horticultural activities and as a basis for a housing settlement have also been initiated.

A programme of examination of soils and irrigation waters for horticultural purposes on mission stations and cattle station homesteads is continuing in conjunction with exploratory traverses designed to yield some overall knowledge of the soils of the region.

Detailed soil moisture studies on an area of irrigated lucerne on the Animal Industry Branch Experiment Farm a few miles south of Alice Springs have progressed to the stage where a clear picture of water consumption by this crop under such arid conditions is beginning to emerge.

(*g*) *Soil Microscopy*.—Several studies of the fine sand mineralogy of soil profiles and their presumed parent rocks have been made at the request of field pedologists.

A study of the fine sand mineralogy of Tasmanian dolerite soils was made in an attempt to determine whether the high proportion of fine sand in the surface soils was derived from the dolerites or from wind accessions. The high proportions of plagioclase and pyroxene and the low proportion of quartz indicated derivation from the dolerites. However, the occurrence of some minerals such as zircon and tourmaline indicates some slight contamination. A loess and wind-blown sand had very high proportions of quartz and a more mixed mineral suite.

A similar study of some basaltic soils showed the surface soils to contain hornblende, zircon, tourmaline, sphene, and considerable proportions of quartz, all of which are theoretically foreign to basalts. Previous similar results have been attributed to accessions of wind-blown materials.

The chief aim of a study of the basaltic soils from the Darling Downs was a comparison of the degree of weathering in three krasnozemic profiles and one black-earth profile. In general the results agreed with the age sequence suggested by the field pedologist for the three krasnozemic profiles while the black earth was much more weakly weathered as would be expected. However, these results were somewhat inconclusive, particularly because of the interesting observation that there was a marked change in proportions of the major mineral species within two of the krasnozemic profiles. This suggests a change in parent material due to either deposition or superposition of different basalt flows.

A number of monoliths of soils of the Riverine Plain have been collected and are being studied in detail. Basic and elementary fabrics have been described and named for some of these materials. In addition, the structure of the various horizons is being studied in detail and particularly the occurrence, relationships, and nature of plane surfaces which are common in many of the profiles.

Attempts have been made to study weathering and soil genesis quantitatively on two soil profiles, an alpine humus soil, and a red earth. The mineralogical evidence strongly suggests that both profiles have been formed on stratified parent materials.

3. Soil Chemistry.

(Division of Soils.)

(*a*) *Head-quarters—Adelaide*.—(i) *Pedological Studies*.—On the basis of the results of the comparative study of terra rossa and rendzina soils of South Australia, it was suggested that these soils should be considered as a continuous sequence and that they would be more appropriately grouped under one term, e.g., " terracal ". To determine the more general applicability of these conclusions twelve profiles from other parts of the world have been examined. The morphological characteristics of these have shown that soil scientists throughout the world hold markedly different conceptions of the soil types. Comparisons have therefore been rather difficult.

For those profiles with a morphology similar to that accepted by Australian workers and taken from localities with a climate similar to that of South Australia, the " colour index " was a useful characteristic for distinguishing between the soils of each group. For other profiles this index was not always in accord with the colour of the soil. The climatic conditions of soil formation may influence the colour of the free ferric oxides and thus the final colour of the soil.

(ii) *Geochemistry*.—The geochemical study has continued of the four main groups of soils (podzolic soils, black earths, brown earths, and krasnozems) developed on dolerite in Tasmania. The laboratory work has been completed and the results are now being examined, interest being specially centred in the redistribution of such elements as cobalt, zirconium, copper, molybdenum, nickel, manganese, phosphorus, and potassium. Knowledge of the distribution of these elements may explain factors involved in the formation of these soils.

In order to evaluate the effects of parent material on the trace element status of these soils a suite of dolerite samples was collected from the Mount Wellington sill and the composition of these studied in relation to soils produced on similar materials. In this way it has been possible to assess the influence on the chemistry and morphology of the soil profiles resulting from differentiation during the cooling of the doleritic magma. Results so far indicate that the stage of differentiation of the parent rock has to some extent influenced the chemistry of the profile but not its morphology. Mineral fractions were also separated from the dolerite samples of the Mount Wellington sill and compared with fractions separated from the clay, silt, and sand of the major horizons of each soil group.

(iii) *Ion Exchange in Soils*.—The method for the measurement of ion-exchange properties has been extensively tested on soils and clays. Some soils showed a tendency to disperse in the salt solutions employed and others gave net charges which depended on the treatment which they had received. Investigations of soil and mineral clays showed them to be slightly unstable under mildly acid conditions so that the method can be used reliably only above pH 4 or 5 depending on the clay mineral present. Below these limits non-exchange reactions interfere.

(iv) *Atmospheric Chemistry*.—Atmospheric studies and rainwater analysis have been extended as a contribution to data being collected throughout the world during the International Geophysical Year. Air samples have been collected regularly at Alice Springs (central Australia) and on the coast south of Adelaide. Significant differences in the carbon dioxide content have been noted between the maritime air and the inland air that has been on the continent for three days. Rainwater samples from Alice Springs have also been regularly examined, but because of the very low rainfall of central Australia it will be some years before it will be possible to evaluate seasonal changes.

The much lower than average rainfall, recorded for Mount Burr and Mount Crawford Forest Reserves during 1957, has been reflected in the composition of the samples taken. During the drier year the ionic ratio sodium: calcium showed a smaller variation between the summer and winter rainfall. Samples from the Commonwealth Research Station at Merbein have also been examined regularly. Reasons for the wide fluctuations noted in the dissolved solids of these samples are still obscure. Rainwater analyses to mid-1957 have been summarized and published; current analyses are being forwarded to the World Meteorological Organization as an I.G.Y. project.

(v) *Spectrochemical Investigations*.—Because of the vast areas involved a detailed survey of the trace element status of the soils of Australia is impracticable. Estimates of this status are being based on the analyses of the relatively small number of profiles sampled from the dominant soils of an area during the course of soil survey operations. Although the samples taken during survey are collected from carefully chosen sites, from the point of view of trace element contents each sample of any one soil group may be regarded as a random sample of that group in the surveyed area. Values found for the trace elements may then be used to give estimates of median concentration and the range containing a given fraction. Average change in concentration with depth is being studied in profiles of different taxonomic groups, and also the average range of concentration in one profile. These four measures have been used to evaluate the trace element status of red-brown earths, terra rossas, and rendzinas from South Australia.

Some work has been done on the " concentration technique " by which trace elements are extracted from solutions and concentrated into a suitable spectrographic base of constant composition. This technique offers considerable promise for the determination of trace elements in the soil solution.

Routine spectrographic determinations on soils and plant materials have been carried out as required to assist other sections of the Division and some outside organizations.

(vi) *Potassium Deficiency on Frodsley Soil*.—A pot experiment on the exhaustive cropping of five Tasmanian soils of varying potassium status is being continued. The pot technique is of particular value in an investigation of this sort where field surveys at Frodsley have revealed the great variability of soil potassium over relatively short distances of a few feet. Only by working on the small scale of a pot experiment can the agronomic significance of these different levels in soil potassium be properly evaluated. At the start of the experiment the potassium status of the selected soils ranged from 0.18 m.-equiv. of exchangeable potassium per 100 g. of soil to 0.85 m.-equiv. per cent., but in none of the soils did the first crop of perennial ryegrass exhibit any signs of potassium tress or respond to applications of potassium. The potassium in the dry matter was in excess of 1 per cent. even in the soil of lowest potassium status, and exceeded 4-5 per cent. in the case of the soils of high potassium status or those to which potassium had been applied. The largest increases of potassium in the dry matter and the largest relative increases of uptake following applications of a potassium fertilizer were found in the soils of lowest potassium status.

Subterranean clover, grown as a second crop, showed a clearly defined response to the residual potassium on the soil of lowest potassium status. The plants on this soil made poor growth in the absence of applied potassium, while the leaves showed an unduly low level of potassium and the characteristic necrosis of potassium deficiency.

Early responses to potassium are already apparent in the third crop and the experiment is being continued to follow the depletion of these soils in exchangeable and other categories of available potassium.

(vii) *Phosphate Studies*.—The field experiment at the Waite Institute (described in the last report) to measure the residual value of superphosphate has been continued. The crop of wheat on the control plots (the seventh crop sown without superphosphate) yielded well, although the percentage of phosphorus in the grain and straw was now at a much lower level than at the start of the experiment. The plots receiving superphosphate showed increases in yields of grain of 20 and 39 per cent. respectively for the two levels used. They showed somewhat larger increases for the amounts of phosphorus taken up by the crops in excess of that taken up from the control plots. A pot experiment has now been started to measure the value of the superphosphate residues in these soils, under controlled conditions, in terms of freshly applied superphosphate and to compare the values so obtained with field results and laboratory extractions of the soils.

Pot experiments have been continued on the placement of phosphate in, and its uptake from, Seddon gravelly sandy loam. Very heavy applications of water soluble phosphate were found necessary for this soil before the test plants showed medium-high levels of phosphate. The highest levels occurred when the applied phosphate was concentrated in a small volume of soil. The uptake of phosphate was at a lower level in the year following its application, but yield responses were good.

The effect of soluble silicates on the efficiency of utilization of superphosphate has been investigated in pot experiments and in the laboratory, by using the phosphate deficient Seddon soil. Best results were obtained when silicate and phosphate were applied simultaneously. In pots the uptake of phosphorus was increased by 10-20 per cent. but the effect did not last for more than one season. Application of silicate to a soil twelve months after phosphate treatment brought about very little or no release of available phosphate. Laboratory studies supported the results of the pot experiments, but additions of silicate would probably have no economic significance.

(viii) *Nutrition of Pines on Lateritic Soils.*—To elucidate the factors controlling the growth of *Pinus radiata* on some poor lateritic soils in Western Australia and South Australia the Division, with the co-operation of the South Australian Department of Woods and Forests, is making a detailed study of the physical, chemical, and microbiological characteristics of the soils of the Second Valley (South Australia) Forest Reserve. The early chemical work is being directed to a study of the phosphorus and nitrogen requirements of these soils. When these are more clearly defined it will be possible to explore other soil factors limiting the growth and nutrition of pines. A pot experiment has been laid down to study phosphorus and nitrogen relationships and to give special attention to the form of phosphate and its placement in the soil. The absorption of phosphate by, and its diffusion through, the soil is also being studied under laboratory conditions. By means of chemical and spectrochemical analysis the normal variation in the mineral composition of specially selected one-year-old pine needles has been determined. The competition for nutrients between recently established pine plantings and the surrounding native scrub regrowth is also being explored.

(ix) *Miscellaneous.*—Several commercially available types of interference filters suitable for use in flame photometry have been examined with particular reference to the isolation of the sodium D line.

Sulphur determinations have been carried out in soils and rainwater. For virgin soils so far examined carbon: sulphur and nitrogen : sulphur ratios show a considerable range of variation.

Soil samples from the United States of America have been examined to provide chemical data for the closer comparison of these soils with their Australian counterparts. Some soils from Vietnam were also examined and these were characterized by an extremely low nutrient status. Routine descriptive analyses for the Pedology Section have been continued as usual and special determinations have been carried out for the Clay Mineralogy Section.

(b) *Queensland Region — Brisbane.* — Experimental work on physico-chemical properties of podzol humus has now been completed. Results of flocculation tests, under conditions of controlled pH, suggest that aluminium predominates over iron in the precipitation of humus in podzol B horizons.

A preliminary survey of the chemical fertility of some representative surface soils in south-east Queensland (excluding coastal areas) has been undertaken. The results show that potassium deficiency is unlikely on all soil types so far examined, the mean for all soils approximating 0.8 m.-equiv. potassium/100 g. Total phosphorus pentoxide contents range from 521 p.p.m. (mean for brigalow soils) to 3,813 p.p.m. (mean for krasnozem); black earths (1,561 p.p.m.) and lateritic red earths (2,431 p.p.m.) were intermediate. " Available " phosphorus pentoxide (modified Truog method) showed no marked deficiency levels and generally exceeded 100 p.p.m. for most great soil groups except red earths which contained 20 p.p.m. Water-soluble sulphate showed adequate levels in all soils, ranging from 9 to 18 p.p.m. sulphur.

Investigations on the isolation of organic matter from soils have been continued. It has been found that cation-exchange resins can be useful in dispersing organic matter. Some preliminary measurements have also been made on the spectral transmission of organic matter suspensions and the changes effected by additions of metals. Attention is also being given to the problem of removing the inorganic material which remains associated with the organic matter even after its dispersion.

A chemical study has been commenced of some samples of acid subsoil clays from the brigalow soils of south-east Queensland. These clays, which are largely of a montmorillonitic type, characteristically exhibit a high degree of saturation by metal ions although the soil pH is often less than 5. Even after removal of the bulk of the naturally occurring salts, the clays seem to be unusually stable under acid conditions.

(c) *South-east Region—Canberra.*—Routine analyses required for the field studies of the south coast of New South Wales, Wagga, and Murrakool surveys have been continued and are nearing completion in several cases.

Preparations of the synthetic crystalline iron and aluminium phosphates have been completed and further determinations of iron-bound phosphate carried out using the modified dithionite method. This concludes investigations carried out by a Research Fellow in this field.

Total analyses of soils, mainly in the Wagga survey, have just commenced to ascertain if there is any chemical property difference between the different layered soils, or of their parent material origin. It is also planned to examine the chemical differences in the mottles of clay in each layer, whenever it occurs. In the main, hand-picked samples from unground material will be analysed, although in some cases monoliths will be used.

(d) *Tasmanian Region—Hobart.*—The investigations at Frodsley are now complete. The Frodsley sandy loam is now a well-documented soil which will serve as a reference for other work on potassium deficient soils. Though Frodsley sandy loam has certain reserves of total potassium, these are largely unavailable to pasture plants for two reasons—the clay B horizon is beyond the main rooting zone of shallow rooted plants, while in the root zone there is little clay, and the reserves of potassium are largely in very slowly weathering primary minerals of the sand fractions.

Investigations of cobalt deficient soils have commenced but have so far been concerned with the application of suitable chemical methods. Cobalt deficiency in sheep and cattle is known to be associated with several groups of soils in Tasmania and of these the krasnozems of the north-west coastal areas have been selected for the initial studies.

(e) *Western Australian Region—Perth.*—Chemical examination has been made of soil profiles from the major soil types at Merredin, Quairading, and Busselton. Additional profiles from Manypeaks and the Swan Coastal Plain have been examined in connexion with the reports in preparation for these areas.

Survey has continued of the composition of rainwaters sampled at monthly intervals. An additional site is to be set up at Quairading, and weekly sampling is being introduced at Dwellingup to provide additional information.

The calcium and magnesium contents of carbonate materials in some soils have been determined. There appears to be some correlation of the ratio of Ca/Mg in these materials with drainage status of the soils and the source of calcium and magnesium.

The solubilizing action of aqueous extracts of jarrah and marri leaves on iron oxides has been studied. Although the results cannot yet be considered in a quantitative way, some solution occurred under sterile, partially aerobic conditions.

Preliminary work on the identification and separation of compounds in the polyphenolic concentrate from the leaves has been commenced. In view of the complexity of the extracts some preliminary separation seems necessary before preparation of two-dimensional chromatograms.

4. Soil Physics.

(Division of Soils.)

(*a*) *Head-quarters—Adelaide.*—(i) *Effect of Soil Water Content on Resistance to Shear and Compression.*—The ring shear machine developed to measure the effect of mechanical forces on soil aggregation has been modified by substituting a ceramic null-point tensiometer for the inside wall of the annular cylinder. This allows the soil water suction to be measured as the soil is compressed and sheared with only negligible changes of water between the soil and the tensiometer.

It has been found that as a bed of aggregates is strained the suction increases considerably. This increase in pore-water suction increases the effective normal load and gives an apparent increase in shear strength. The resulting shear strength of the unsaturated soil can be calculated from the shear strength characteristics of the saturated soil and the porosity.

The shear strength behaviour of agricultural soil differs from that predicted by recent soil mechanics work in that surface soils are not uniformly overconsolidated. Elucidation of this problem will considerably simplify future investigation of soil strength both in agriculture and civil engineering.

(ii) *Role of the Cultivated Layer in Controlling Water Movement.*—Following reports of Russian work on the effect of the state of the cultivated layer on soil water loss, laboratory trials have shown big effects of clod size on the evaporative loss of soil water. Soils made up of clods 2.5, 25, and 50 mm. in diameter and uncultivated soils have been exposed in a wind tunnel to different wind speeds and with radiant heating. As an example of the effects observed: under normal heating, giving rise to soil surface temperatures of 30° C. at a wind speed of 5.5 m.p.h., water losses for 24 hr. were 1, 7, 7.5, and 6.3 mm. for the four treatments in the order given above.

For the no-heat case and with impermeable spheres in the place of soil, the effect extends to at least 4-in. depth and is probably due to differences in air pressures set up at the soil surface. In the case of heating without wind the effect can be explained by air convection both within and above the soil surface.

The observed phenomena can explain the fallacy of deep ploughing to conserve soil water, and the loss of water from deep clays through self-generating cracks, and should throw more light on the problem of soil water conservation by means of soil mulches.

(iii) *The Control of Soil Fertility by Tillage.*—Arising from the concepts of inaccessible sites (Annual Report 1956-57) where organic matter and plant nutrients might be protected from microbial activities, several experiments are in progress to study problems associated with the control of soil fertility by tillage.

Pot experiments have been set up in which the effect of clay content, i.e. different ratio of inaccessible sites to total volume, on the breakdown of incorporated organic matter is being investigated. This work will be extended when new infra-red gas analysis equipment is installed.

In another experiment the mobility and the storage of organic compounds in the soil is being followed with the aid of radioactive tracers. This project is aimed at defining the best sort of soil structure for supplying stored nutrients to crop plants, and for storing organic matter when the soil is being reconditioned under pasture.

(iv) *The Neutron Scattering Method of Measuring Soil Water Content.*—Suitable field portable apparatus has been developed and the emphasis of this project has shifted to a re-examination of the calibration and treatment of the observations. The effect of absorption of slow neutrons by the soil solids has been investigated. In first work, it was assumed that the macroscopic absorption cross sections of the solid components of soils were the same. But improvement in calibration accuracy can be obtained by recognizing that, when making measurements on a new soil type, the calibration should be verified with several direct determinations of water content.

Aspects of measurement of water content at the soil surface are receiving attention. "Semi-infinite medium" geometry presents great difficulty in calibration. Placing a reflector tank of water over the source of neutrons when it is located at the soil surface has been tried, and these results are being considered at present.

(v) *Measurement of the Water Content of Brown Coal.*—During 1957, an attempt was made to monitor the water content of the crushed and sieved coal during the briquetting process at the Yallourn Briquette Works, Victoria. A continuous measurement of the initial water content is desired in order to provide information about the drying needed before the coal is moulded into briquettes, whose quality depends strongly on the water content at moulding. The neutron moisture meter was taken to Yallourn and an experiment performed at the invitation of the State Electricity Commission, Victoria. Results were encouraging, but the required accuracy was frustrated by changing bulk density of coal as it passed through the chute into which the neutron probe had been inserted. Further work is now being undertaken in cooperation with the Isotopes Section of the Australian Atomic Energy Commission Research Establishment to measure bulk density and water content simultaneously, each technique using a radioactive source.

(vi) *Evaporation from the Land Surface and the Ground-water Hydrology of a Portion of the Upper South-east, South Australia.*—The investigation of the origin of the ground-water, and the evaporation from the vegetation in portion of County Cardwell has continued. This is a cooperative project between the South Australian Department of Mines and C.S.I.R.O. The present stage of the investigation has almost concluded. The results are briefly that:

Evaporation from either the natural heath vegetation or an established lucerne and phalaris pasture is the same for a total period of a year, though seasonally there are differences in the rates of evaporation.

All the water stored in the soil during the excess of winter rainfall is used up in evaporation and none accedes to the ground-water, which is at an average depth of 30 feet, in years of normal rainfall.

The ground-water flows directly towards the Coorong and the sea at the western boundary of the experimental area.

(vii) *Land Drainage.*—The saturated permeability of the soil of the irrigated swamp (Jervois) near Tailem Bend has been measured. This is a preliminary investigation to obtain data to be used in assessing the advantages of better drainage of the soils of the Murray swamps. This project is being undertaken jointly with the South Australian Department of Agriculture.

(viii) *The Movement of Water and Air through Soil Pores.*—The rate at which water can move through soil depends upon how much of it is made up of pore space and how large the pores are. An equation developed on this basis enables permeability of porous materials to be calculated when the sizes of the pores are known. The equation has been tested satisfactorily on flow of water and air through sands and porous rocks, and its application to soils is under study. Its use for unsaturated soils is of particular interest, since permeability measurements are difficult to make in such cases. As a consequence of this work on permeability, information has also been gained on the effect of pore space on gaseous diffusion in soils.

(ix) *Use of Gypsum in Irrigation Water.*—The use of gypsum dissolved in irrigation water has been found to help the physical condition of difficult clay soils at Deniliquin, New South Wales. Preliminary investigation of the effect on the soils was encouraging, and this was followed by experiments with plants at the C.S.I.R.O. Regional Pastoral Laboratory. These have shown that establishment of pastures is much improved by this treatment.

(x) *Forces between Clay Crystals.*—From measurements of the macroscopic swelling in salt solutions of oriented flakes of pure clays the general variation with distance of the forces between clay crystals may be deduced, since swelling depends on a balance between attraction and repulsion forces. The forces between the basal and edge surfaces of the clay crystals may be distinguished by adding various organic substances such as quaternary ammonium salts to the clay and also by varying the pH of the salt solutions with the use of dilute buffers.

(xi) *Sealing of Soil in Earth Dams.*—The possibility of using small quantities of a dispersing agent such as sodium tripolyphosphate to prevent water loss from earth dams is being investigated so that dams may be sited in the best hydrologic position irrespective of soil texture. Laboratory experiments are encouraging and indicate that soils containing as little as 5 per cent. clay form adequate seals if 0.1 per cent. of a dispersing agent is added.

(xii) *Permeability of Soils to Water.*—An extension to the laboratory method of measuring unsaturated soil water permeabilities has been under development. This consists of a device for determining the distribution of water content in the soil columns by use of a beam of gamma rays, and supplements the suction measurements in the soil columns. It is proposed to use this technique also for studying evaporation loss from soil surfaces, and the influence of temperature on water movement.

(xiii) *Miscellaneous.*—Determinations of water content-suction relations, and of soil aggregate density, have been carried out continuously throughout the year on a routine basis. Recordings of the performance of a solar water heater, over a period of two years, for the Engineering Section have been completed. Measurements have continued on moisture movements under houses, and projects have been commenced relating to moisture gains and losses in soils in agricultural and forestry problems.

(*b*) *Queensland Region—Brisbane.*—(i) *Structure Alteration in Cultivated Soils.*—Adverse climatic conditions have severely affected the conduct of this experiment on the Darling Downs on Mywybilla clay and crop failures have occurred in the two cropping years to date. This has been principally due to lack of water at flowering, and, since the rainfall during the fallow periods has been low, the significance of deep cultivation in increasing soil storage has not yet been conclusively tested. The increased evaporation from the soil associated with deep working suggests, however, that in this area of rather unreliable rainfall it might be hazardous to cultivate deeply unless substantial benefits from this culture can be demonstrated. Germination of wheat on the trial area was excellent for the 1957 planting, despite the poor reputation of this soil in this respect, and no significant differences were found for three depths of cultivation and two superimposed rolling treatments. This result was rather surprising in view of expectations when the experiment was commenced and must be attributed to special climatic conditions which favoured germination. The experiment is being continued in 1958 when it is hoped that favourable conditions may allow more definite conclusions to be obtained.

(ii) *Water Content Changes in Natural Soils.*—Observations have been continued on the joint project with the Ecology Section, Division of Plant Industry, on forest communities in the Lismore District, New South Wales. This project will be terminated in early summer 1958. Physical environment has not been found to be very different for some of the plant communities, which suggests that chemical differences are primarily responsible for the floristic separation. Chemical analysis of the soils has been carried out to check upon this apparent difference in fertility. Large permeability changes accompanying disturbance and removal of rain-forest have been attributed principally to alteration in biotic factors, since soil measurements do not reveal large or consistent changes to explain them.

As part of the instrumentation of this project, a study has been made of the characteristics and performance of Livingston atmometers as ecological instruments for integrating various climatic factors upon evaporation. In particular, the use of these instruments to give an estimate of solar radiation has been examined. Results obtained differ from those reported overseas and the reason for these differences has been determined.

(*c*) *South-eastern Region—Canberra.*—Research activities have been limited by shortage of staff, but routine particle size analyses and other physical determinations have been carried out during the past year. These were the usual particle size analyses of field samples and some detailed analyses of sand fractions by an end withdrawal tube.

Normal dispersion methods as used in the Division did not satisfactorily disperse soils described as highly subplastic. Microscope examination showed large numbers of clay aggregates (up to 50 per cent.) remaining in the fine sand fraction. Better, but not complete, dispersion resulted after treatment with dithionite ($Na_2S_2O_4$) for the removal of free iron oxides.

5. SOIL MICROBIOLOGY.

(Division of Soils.)

Research has been undertaken along four general lines in order to study the role of microorganisms in soil processes which influence the growing plant as soil fertility or which influence the genesis of specific soil types. Studies have been undertaken to characterize the microflora of the rhizosphere of the plant, with particular emphasis upon that of tomato, subterranean clover, Wimmera ryegrass, and *Phalaris tuberosa*. Substances excreted by roots which affect the growth of bacteria have been studied, and the principal groups of organisms associated with roots subjected to scrutiny. The symbiosis of root-nodule bacteria of the genus *Rhizobium* with legumes has been studied with particular reference to the characterization of the *Rh. leguminosarum*, and to the influence of calcium on the establishment of the symbiosis as a factor in pasture establishment in infertile soils. Studies have been made upon the role of microorganisms in releasing phosphorus from insoluble phosphates. Attempts have been made to ascertain the mechanism of release and to study it by analogous chemical reactions; an assessment has been made of the incidence of phosphate-solubilizing microorganisms in the rhizosphere microflora. Studies on soil organic matter have been continued by the fractionation of humus and comparison of the products with melanins polymerized from microbial end-products and by microbial enzymes as models. In this way biochemical processes carried out by microorganisms in formation of organic matter in soils can be defined.

(*a*) *Rhizosphere Studies.* (i) *Root Exudates.*—The study of the effects of environment on exudation has been continued. Light intensity had a marked effect on the exudation of amino acids from subterranean clover roots, with greater amounts of aspartic acid, serine, glutamic acid, and β-alanine exuded at the higher light intensities. With tomato root exudate, the amounts of most amino acids were less at the lower light intensities, although serine and glycine were exceptions in that their amounts increased under reduced light intensity. Exudation by tomato and clover roots was greatly increased when plants were grown at higher temperatures; with clover roots, the predominant constituent of the exudate at the higher temperatures was asparagine. Calcium nutrition and aeration had little effect on the exudation from the roots during the first 4 weeks of growth of *Phalaris tuberosa*, subterranean clover, and tomato. The presence of microorganisms on and around tomato roots altered the spectrum of amino acids found in the nutrient solution, thus indicating the importance of maintaining sterility in root exudate studies.

(ii) *Root Surface Bacteria of Subterranean Clover and Wimmera Ryegrass.*—Over 300 bacterial isolates from the surfaces of subterranean clover and Wimmera ryegrass roots were obtained by the random selection of colonies growing on dilution plates prepared from roots washed free of soil. All isolates were examined for their morphological, staining, physiological, and biochemical characteristics and identified as genera. In cases where the identification of some of the genera, e.g. *Pseudomonas* and *Achromobacter*, depended on the success of the flagella strain, precise naming of the genus was not possible. However, it was found that over half of the organisms were *Arthrobacter* spp., were mainly Gram-negative, and showed pleomorphic, branched, rod, and coccoid forms. The remaining main genera were *Micromonospora, Nocardia, Mycoplana, Mycobacterium, Achromobacter, Flavobacterium, Bacillus, Serratia, Sarcina*, and possibly *Pseudomonas.* Although 151 isolates were taken from clover roots only one was identified as *Rhizobium.*

(iii) *Effect of Pasture Sward on Composition of Rhizosphere Microflora.*—In conjunction with the Agronomy Department, Waite Agricultural Research Institute, a study has been made of the numbers of bacteria in the rhizospheres of subterranean clover and Wimmera ryegrass growing together. Treatments of four levels of nitrogen were used to obtain swards with different degrees of clover and grass dominance. In spite of the high variability between replicate groups of plants, it was found that during the first eight weeks of growth the greatest numbers of microorganisms occurred at the high nitrogen level for both grass and clover.

(*b*) Rhizobium *Studies.*—Particular attention has been paid to the pea-vetch cross-inoculation group associated with grain legumes. About 100 strains isolated from *Vicia* (13 spp.), *Lathyrus* (9 spp.), *Lens, Pisum,* and *Cicer* have been studied in pot experiments in the greenhouse for their effectiveness in association with hosts of this group. The range has now been extended to eight species, viz. *Vicia faba* var. *minor, V. atropurpurea, V. sativa, Lathyrus ochrus, L. cicera, L. sativus, Pisum sativum,* and *Lens esculenta.* The patterns of effectiveness shown vary widely and range from strains capable of nodulating all test hosts to strains with restricted specificity.

The bacteriology of the group has also been studied with the view to correlating host-plant relationship with biochemical activities and cytological behaviour. Again, the variations between strains have been diverse and have failed to yield readily determinable criteria capable of correlation with plant reactions. Of particular interest has been gum production, the amount and type of which can be correlated with carbohydrate nitrogen balance on the one hand and tendency to produce acidic products of metabolism on the other. In this way it is possible to account for the varying degrees of gum production, and thus colony characteristics, found in this species.

Difficulties in the establishment of subterranean clover and lucerne in deep sands of mild to strong acidity in the south-east of South Australia have been largely overcome by applications of lime with superphosphate and trace elements. Greenhouse experiments have been undertaken to study the mode of action of lime in a Mount Compass sand (pH 5.2-5.5). The major effect is upon the calcium nutrition of the host, and cannot be replaced by ameliorating pH with magnesium. Under a high lime regime, nodulation is successful whether artificially inoculated or derived from natural sources (probably mostly seed-borne), but without applications of lime nodulation is scanty or absent and the plant suffers from acute nitrogen deficiency.

(*c*) *Solubilization of Phosphates by Microorganisms.*—(i) *Mechanisms of Solubilization.*—Previous experiments had shown that the blackening of ferric phosphate particles was carried out by organisms producing hydrogen sulphide. This suggested that hydrogen sulphide reduced ferric phosphate to black ferrous sulphide with the release of phosphate. This reaction was studied chemically, calcium, aluminium, and ferric phosphates being used.

(ii) *Incidence of Solubilizing Organisms.*—An estimation was made of the number of phosphate solubilizing organisms present in the rhizosphere of four plants (subterranean clover, Wimmera ryegrass, wheat, and perennial rye) and in non-rhizosphere soil. About 30-40 per cent. of the isolates from the rhizosphere showed solubilization of apatite on initial subculturing, but only 10-17 per cent. of the soil isolates showed similar activity. Many of these organisms lost their capacity to solubilize apatite after continued subculturing, and the property could not be restored. The amount of solubilization varied considerably, but was not proportional to the drop in pH. The organisms were represented by many of the genera commonly found in soils.

An examination of the number of solubilizers at the root surface of subterranean clover and Wimmera ryegrass showed the presence of 44 and 30 per cent. respectively.

(*d*) *Soil Humus Studies.*—The condensation of amino acids with quinoids formed from oxidation of phenolic substances by phenolases from plant and microbial sources has been studied to provide a series of substances which are comparable with soil humus fractions. Chromatograms and acid hydrolysates of these products show that, whilst they are not identical with the melanins derived from humus, they serve as useful models to understand the sort of units that the complex humic polymers contain. The amino acids in acid hydrolysates of soil organic matter must apparently be condensed in that form rather than in the form of proteins, since humus materials give no positive tests for proteins, although synthesized polymers such as ligno-proteins, tanned proteins, and protein complexes synthesized as " browning reaction " products do so.

6. CLAY MINERALOGY.

(Division of Soils.)

(*a*) *Structure of the Micas.*—The refinement of the muscovite structure is nearly completed. Three-dimensional bounded Fourier projections have been used, both to increase the accuracy and resolution of the projections. By projecting slabs which are only half the thickness of the unit cell it is possible to resolve atoms practically completely from each other.

The parameters determined for the potassium, aluminium, and silicon atoms appears to be very near their final values, and these are found to represent considerable departures from the ideal structure. The oxygen atoms are not yet so definitely fixed, though a marked distortion of their network is clearly revealed.

From the results it seems possible to explain various features of the muscovite structures.

(*b*) *Phosphate Minerals.*—Using techniques which had been developed earlier for the concentration and identification of the soil phosphate minerals, gorceixite and florencite, further studies were made on the distribution and nature of these phosphates. The minerals had been identified in many soils developed on basalt (see previous annual reports). During the last year the minerals have been identified in a variety of soils from Australia and several from Barbados and the United States of America. It is significant that some of these soils, terra rossas and rendzinas, were high in calcium carbonate. The wide range of occurrence indicates that these minerals are very stable in soils and are not rarities as their complex chemistry might suggest. Detailed analyses of several soil profiles showed that gorceixite and florencite were not present as a solid solution, but that in those profiles where the phosphate was high in barium and rare earths both gorceixite and florencite were present. Gorceixite, the barium member, appears to be the more resistant of the two, as, relative to florencite, it tends to be more concentrated in the upper layers of the soil and its average particle size is a little greater than that of florencite.

(*c*) *The Nature of Free Iron Oxides in Soils.*—The crystalline iron oxides, haematite, goethite, &c., can be identified by X-ray diffraction methods and have long been recognized as common minerals of soils. More recently, differential thermal analyses has been used to identify amorphous iron hydroxides in soils, the identification being based on an exothermic reaction at about 320° C. This reaction occurs in many Australian soils, but a detailed study has shown that the exotherm is not due to amorphous iron oxide but due to organic matter which is not destroyed by the normal treatments used to remove organic matter from the soils. The exotherm at 320° C. thus cannot be used by itself as a criterion for the presence of amorphous iron oxide, and many of the reported occurrences in this form of iron oxide may be in error. Amorphous iron oxide is probably very rare in soils.

(*d*) *Computer to Aid Structure Factor Calculations.*—A simple mechanical device had been previously designed which allowed values of cos $(hx+ky+lz)$ or sin $(hx+ky+lz)$ to be read directly from tables of cos hx. These functions are often calculated in studying triclinic crystals.

This devise has now been redesigned to permit the direct tabulation of cos $(hx+ky)$ cos lz or the equivalent. The device is simple and rapid—300 values of cos $(hx+ky)$ cos lz were tabulated in 23 min. in one test run. The new design will prove useful in studies of monoclinic crystals.

(*e*) *Firing Characteristics of Certain Weathered Schists.*—The Onkaparinga Brickworks, South Australia, had experienced difficulties in that certain clays crumbled on firing whilst adjacent clays were quite satisfactory. In the course of a mineralogical examination of these clays, it was found that partially weathered biotite was a constituent of those clays which crumbled. By contrast any biotite present in the satisfactory clays was found to be either highly weathered, or unweathered. A search of the literature showed that only partially weathered biotite should exfoliate markedly on heating, and the exfoliation was confirmed in the laboratory.

(*f*) *Miscellaneous.*—The techniques of mineral analyses, by X-ray diffraction, and elemental analyses, by X-ray spectroscopy, have been developed to a high degree in this laboratory. Much service work is undertaken for other sections of the Division, and because these techniques are not generally available, where warranted, help is given to other organizations.

Clay mineral analyses have been made on soils from the south coast of New South Wales, the Merredin area of Western Australian, Darling Downs, Queensland, and various parts of Tasmania. Mineral analyses were made on a number of samples for the Chemistry and Physics Sections in conjunction with their research projects on phosphate fixation, geochemistry, and swelling.

The Queensland Department of Stock and Agriculture and several departments of the Adelaide University are amongst those for whom X-ray diffraction studies were undertaken.

Developmental work was carried out on the fluorescent X-ray spectograph to make the theoretical and practical aspects of the techniques more reliable. The spectrograph is in almost continuous use both as a research tool in the Section and as an instrument for routine analyses. The wide use of the instrument can be gauged from the variety of analyses performed with it during the year. Some of these are as follows: zinc in soils in connexion with fertility studies in Western Australia and Queensland and geochemical studies in Tasmania; zinc in clover leaves, for Waite Institute, and in Rhodes grass from Queensland for the Division of Plant Industry; iron in potato leaves for Waite Institute; strontium in clays, as a method of exchange capacity determination, for the Division of Industrial Chemistry; strontium in natural salts and carbonates, and cadmium in zinc sulphides for the Geology Department, and tungsten in biological materials for the Physics Department of the University of Adelaide; barium in plants for the Department of Agriculture, New Zealand. Other samples were analysed for vanadium, gallium, zirconium, titanium, copper, chromium, manganese, lanthanum, cerium, praseodymium, and neodymium. Because of the nature of the material or in some cases because of the limited amount available, many of the above analyses would have been very difficult by conventional methods.

7. SOIL MECHANICS.

(Division of Soils)

(*a*) *General.*—There has been a steady increase in the Soil Mechanics Section's contact with engineering problems and in the engineering community's awareness of the potentialities of soil mechanics research, to such an extent that some expansion of the scope of the Section has become desirable.

The work of the Section is now directed to two principal fields of civil engineering research:

(i) Soil mechanics in relation to building research—in which field the Section accepts responsibilities compatible with the programme of the Division of Building Research.

(ii) Soil mechanics in relation to road research—in which field the Section operates in collaboration with State Road Authorities on specific projects, and also accepts responsibilities for civil and military road research projects of a comprehensive nature.

The principal projects affecting building research are—
Shallow foundations for domestic-type structures; deep foundations for major structures.

The principal items related to Road Research are—
Water movements in pavement subgrades; soil stabilization.

(*b*) *Foundation Studies.*—The principle of regional studies of foundation characteristics has been followed in current investigations.

Typical foundation problems for domestic buildings on clay soils in a winter-rainfall, summer-drought climate are being studied in a comprehensive programme at the satellite town of Elizabeth, South Australia, and in a spasmodic investigation of the townships of the Wimmera region of Victoria. The complementary problem of shallow foundations on clay soils in a summer rainfall zone has been examined in the towns of central Queensland.

In regional studies of shallow foundation problems, the distribution of the soils is first defined by pedological studies. On each soil so defined a measure is then made of the physical properties affecting foundation design. It has been widely accepted in practice that a soil type, in the pedological sense, possesses reproducible engineering properties. This hypothesis is still subject to review, and is receiving particular attention in the regional study of Elizabeth where a total area exceeding 10 sq. miles has been mapped in detail. The relevant soil mechanics investigations (including studies of seasonal moisture, volume change, shear strength, and consolidation characteristics) are proceeding.

Deep foundation studies have been confined to the South Melbourne basin which is an area of soft estuarine muds overlying a weathered siltstone and to the Elizabeth area which is underlain by a firm to stiff clay.

Investigations for the foundations of the new King Street Bridge have provided an opportunity for an extensive study of the South Melbourne deposits. The upper layer, to depths of about 90 feet, comprises soft, sensitive estuarine muds (of late Quaternary age—approximately 10,000 years). These deposits overlie a Silurian shale which is extensively weathered, presumably as a late Tertiary land surface. Bores to depths exceeding 200 feet have demonstrated the continuous presence of comparatively soft silty clay layers (with shear strength of the order of 2 tons/sq. ft.) in steeply dipping strata. By contrast, the adjacent unweathered rock has shear strengths exceeding 50 tons/sq. ft. The complexities of these strata create many foundation problems in connexion with the current King-street Bridge project, and, as a result, an elaborate series of bores is planned to produce undisturbed samples for inspection and testing.

Foundation studies in the substrata at Elizabeth, South Australia, have been restricted to attempts to define the pattern of variability of the morphologically uniform clay over a lateral extent of several square miles and throughout a depth range of 50 feet. Results to date from triaxial compression studies from three bores indicate substantially constant strength parameters for all depths at each site.

(*c*) *Sub-grade Moisture Studies.*—The importance of a quantitative understanding of moisture movements in pavement sub-grades has been recognized for some years, but little or no action of a sufficiently comprehensive nature has been taken to elucidate the problem. In an attempt to compile a rational experimental account of sub-grade moisture conditions throughout Australia, the Section has undertaken the planning, coordination, and interpretation of an investigational programme sponsored by the State Road Authorities. When complete this programme will include each State and will embrace the dominant soils and climatic conditions of the continent. To date, preliminary installations have been made at only three sites. Attempts are being made to coordinate the Australian programme with similar work overseas. As a first step in this direction, a comparison has been made of South African and Australian data, techniques, and external controls. Although this comparison was facilitated by an exchange of principal workers from each country, no general conclusions could be reached owing to the paucity of parallel evidence. Further programmes in each country are being planned to eliminate this difficulty.

(*d*) *Soil Stabilization.*—A programme of investigation into the applicability of techniques of soil stabilization to the soils and soil conditions of the Australian mainland and nearby areas of interest has been undertaken on the basis of a research contract. The working hypothesis accepted in the formulation of this programme has been that the characteristics of any natural soil determining its response to any stabilization procedures are reflected in the pedological classification of the soil. Preliminary work undertaken so far has been limited to the examination of this hypothesis in relation to available overseas evidence, and to the selection of a range of soils to represent the major pattern of Australian conditions.

III. PLANTS.

1. General.

Research on plants is essential to Australia's agricultural and pastoral industries. Investigation of plant problems is concentrated at the Organization's Division of Plant Industry which has its headquarters in Canberra and is the Organization's oldest Division. The work of the Division, which has experimental farms and field stations throughout the Commonwealth, is described in this Chapter.

The research of the Division is complementary to the activities of the State Departments of Agriculture, whose particular function it is to serve the more immediate local needs of the agricultural industries.

Because of the importance of pastures in the Australian economy and also because of the many problems of establishment, utilization, and maintenance of improved pastures throughout the diverse climatic regions of Australia, the Division has for many years been primarily concerned with these matters. Research in ecology, plant breeding, and plant nutrition has been pursued with the main aim of improving pastures. However, work is also directed to other crops of economic importance such as tobacco and wheat. Complementary to these activities, strong research teams have been established in genetics, microbiology, and biochemistry.

Allied work on mineral nutrition of plants carried out by the Division of Biochemistry and General Nutrition is described in Section 8 of this Chapter.

Work on special local problems of irrigation districts is undertaken by the Irrigation Research Stations at Merbein and Griffith, New South Wales (see Chapter IV.).

The Division of Entomology is carrying out work on weed control, insect pests of pastures and crops, and insect vectors of virus diseases (see Chapter IX.).

The Division of Soils is studying the microorganisms in soil as they influence the growing plant (see Chapter II., Section 5).

The Division of Land Research and Regional Survey is carrying out broad-scale ecological surveys in the underdeveloped arid and semi-arid regions of the continent to assess their land use potential and investigate problems of agricultural and pastoral development. The work of these regional surveys is reported in Chapter XI., Section 2, and the Division's investigations on crops, fertilizers, plant diseases, tillage, and native and introduced pastures under dry-land cultivation at the Katherine Research Station, and under irrigation at the Kimberley Research Station, are reported in Chapter XI., Section 3, et seq.

In Chapter XXVII., Section 5 is recorded the work of the Division of Meteorological Physics on meteorological aspects of agricultural problems.

The work of the Fodder Conservation Section is reported in Section 21 of this Chapter.

In Chapter XVI., Section 12, is recorded the work being undertaken by the Wool Textile Research Laboratories on the digestibility of pasture plants.

In Chapter XVII., Section 7 (c), is reported the work of the Division of Industrial Chemistry on alkaloids in Australian plants; in Section 7 (d) the work of this Division on stock poisons in plants injurious to animals; and in Section 7 (e) the Division's basic research on the nature of chemical compounds exuded during growth by the roots of plants.

Division of Plant Industry.—Following the completion of the laboratories at Mareeba, the Tobacco Research Institute was officially opened by the Queensland Minister for Agriculture on 10th October, 1957. Staffing of the Institute has been completed and an active research programme has commenced. During the year the Director, Dr. D. W. Goodall, left on a six months' overseas visit to research centres and major tobacco-growing areas.

A new programme of research has been commenced at the Regional Pastoral Laboratory at Deniliquin, New South Wales. The Laboratory and its associated Falkiner Memorial Field Station is to be a centre for research on problems associated with the growing of pastures and crops under irrigation on the principal soil types of the surrounding irrigation districts.

It is proposed also to base the Division's main research on semi-arid native grasslands at Deniliquin and to use this as a centre for studies of the establishment and maintenance of sown pasture species under dry-land conditions. Mr. L. F. Myers has been appointed Officer-in-Charge, and an active programme of work is already in progress.

The Chief of the Division, Dr. O. H. Frankel, who is at present visiting overseas research organizations, has been invited to contribute to the International Genetics Congress and the annual meeting of the American Society of Agronomy.

A new laboratory building to accommodate the Genetics and Microbiology Sections and the Herbarium has been completed at Canberra. New buildings are in the course of construction at Brisbane to house the Plant and Soils Laboratory, which has since its establishment been located in buildings of the University of Queensland.

The new experiment station at Ginninderra, Australian Capital Territory, is ready for occupation, although it is not expected that existing experiments at the old station at Dickson will be completed for some years. The new station will provide a range of soils and environments typical of much of the Southern Tablelands of New South Wales and will greatly enhance the scope and variety of the Division's research in a number of fields. In particular, the Division will have an opportunity of extending its research on the utilization and management of pastures and will be able to include experiments involving cattle as well as sheep.

2. PLANT INTRODUCTION.

(Division of Plant Industry.)

(*a*) *International Exchange.*—International co-operation in this field continued to increase. Material received included a collection of grasses from the United States of America; varieties of peas, vetches, cereals, and pasture plants from Germany and Czechoslovakia; soybeans and peanuts from Indonesia; and a large collection of indigenous regional strains of lucerne from the Union of Soviet Socialist Republics.

(*b*) *Agronomic Trials.*—(i) *South-eastern Australia.*—Three selected strains of Russian comfrey tested at Canberra showed a marked difference in productivity but withstood summer drought conditions. All strains recovered rapidly after cutting at 30-day intervals. These strains have now been released for further testing throughout Australia.

Drought conditions in most of eastern Australia imposed considerable stress on pasture plants being tested in marginal environments. Aberystwyth strains of perennial ryegrass and English strains of other grasses, which had previously shown promise, suffered heavy mortality at Canberra and Armidale. Introductions of *Bromus inermis* and tall fescue showed drought resistance and were relatively productive under the adverse conditions.

Introduced lines of *Phalaris tuberosa* from Turkey, Morocco, and Algeria continued to show greater persistence than the Australian commercial variety under marginal conditions at Condobolin and Wagga and in north-western New South Wales. The Australian variety continued to be outstanding on the Tablelands. Comparisons are in progress between the climatic and other environmental factors of the places of origin and areas in Australia.

In preliminary trials the sterile hybrid phalaris, Ronphagrass, from South Africa, the "Superior" strain of *Phalaris arundinacea* from Oregon, and *Phalaris coerulescens* from Portugal appear suitable for some Australian conditions.

In comparison studies between *Phalaris tuberosa* and other grasses at Canberra perennial ryegrass, prairie grass, and similar species do not equal *Phalaris* in productivity over a period of years. This is due primarily to the inability of these species to compensate by reseeding under conditions of erratic rainfall for plant mortality and decreased individual plant productivity.

(ii) *Western Australia.*—In the third year of a comparative sward trial of strains of *Phalaris tuberosa,* at Kelmscott, introduced strains from the Mediterranean region continued to show better productivity and persistence than the commercial type. Similar trials with *Phalaris coerulescens* were commenced.

Introduced strains of cocksfoot, mainly of Mediterranean origin, showed marked differences in yield and persistence following the first year's cutting treatment. Two French strains showed exceptional seedling vigour, good persistence, and productivity.

Twenty-four species and strains of *Trifolium* are being tested under conditions in which subterranean clover does not thrive. Seed size appears to be an important factor in the early growth. Subsequent development shows inter- and intraspecific variation.

An introduced common vetch from Algeria has shown early maturity and good yield at all trial centres. An early maturing strain of the woolly-pod vetch (*Vicia dasycarpa*) from Turkey under trial at Kojonup has also shown promise.

Regional trials in marginal wheat-belt areas have been continued and extended during the year. Some relatively late flowering annual clovers have shown a capacity to mature seed satisfactorily even though in these regions the interval between flowering and maturity is short. Collections of pasture plants have been supplied for trials at Esperance, and for trials under irrigation at Wiluna.

(iii) *Queensland.*—A large number of introduced grasses were tested under drought conditions in grazing trials at Samford and Lawes. *Urochloa* species, Rhodes grass, and species of *Panicum* showed drought resistance. Many *Paspalum* species did not survive.

Pasture legume grazing trials covering a wide range of species, soil types, and climatic conditions have been established at Lawes, Samford, and Beerwah.

Introductions of soybean have been tested in field trials in south-east Queensland. Those originating in lower latitudes have been generally superior to those from higher latitudes. The best yields have not exceeded 1,000 lb. per acre. Further selective and breeding work must precede the development of varieties suitable for commercial use.

Field experiments are in progress to assess *Phaseolus mungo* and *P. aureus* as possible pulse crops for Australian tropical areas.

(*c*) *Plant Geography.*—A study of the world distribution of grasses is being undertaken, to assist in defining the most suitable regions for obtaining plant introductions for Australia. Studies of the grass tribes Andropogoneae and Paniceae have been completed. Grass flora of overseas regions have been compared with those of the major pastoral districts of Queensland and New South Wales.

3. GENETICS.

(Division of Plant Industry.)

(*a*) *Subterranean Clover.*—(i) *Subspeciation.*—Further crosses have been made between strains incompatible with the Tallarook group. A number of these F_1's proved to be inviable; others are being grown for further study.

(ii) *Natural Selection.*—In all natural environments unfavorable seasonal conditions resulted in poor germination and seed setting. In irrigated plots at Deniliquin there were fewer weeds in mixed-hybrids plots than in plots with mixed pure lines.

(iii) *Flower Initiation.*—A study of apical meristems has indicated that a process with a positive temperature coefficient may limit flower initiation. This process is additional to the vernalization and night inhibition processes previously known.

(iv) *Seed Dormancy.*—Selection experiments indicate that the embryo itself, as distinct from the testa, plays a part in determining differences in dormancy.

(v) *The Effect of Temperature and Strain on Growth Rate.*—Laboratory studies on five strains at various temperatures showed that temperature, strain, and temperature x strain interactions were significant for growth indices.

Strain differences in relative growth rate were determined largely by production per unit leaf area rather than by differences in the ratio of leaf area to plant weight. Temperature affected growth through both these components.

(vi) *Selection for Sward Productivity.*—Replicated swards from 10 F_3 lines have been sown at Deniliquin, Kojonup, and Canberra. Results from Kojonup indicate that at least one line may be of commercial value.

(vii) *Resistance to Stunt Virus* (In collaboration with the Division of Entomology).—From 321 strains tested for resistance to stunt virus, five have been selected which showed possible resistance. One of these, Tallarook, showed high resistance, and inheritance studies are in progress.

(*b*) *Lucerne.*—(i) *Winter Yield.*—Studies are complete of inheritance and selection for winter growth in strains and their F_1's. Further selections are being made following back crossing and top crossing. Incorporation is being attempted of high winter yield in creeping rooted lines.

(ii) *Combining Ability in* Medicago sativa *and* M. falcata.—Significant specific combining ability effects for forage yield were found among F_1's. High correlation coefficients between forage and seed yields, and the " within line " genotypic correlations indicate the possibility of improving both forage and seed yields simultaneously and of utilizing heterosis for pasture lucerne breeding.

(iii) *Cold Hardiness in* M. sativa.—The inheritance, and general and specific combining ability, of cold hardiness has been determined in *M. sativa* by using an electrical conductivity method.

(iv) *Lucerne Strain Trials.*—Trials were conducted at Canberra, Armidale, and Deniliquin. At Deniliquin, Hairy Peruvian, Indian, and African gave outstanding winter yields, the winter growth rate being approximately 60 per cent. that of summer growth rate compared with 44 per cent. for Hunter River.

(*c*) Phalaris *Species.*—(i) *Interspecific Hybridization.*—To obtain data on the use of synthetic alloploids in plant breeding, a series of hybrid combinations between different strains of *P. tuberosa* and *P. arundinaceae* and of *P. tuberosa* and *P. minor* have been made. The hybrids obtained are uniformly sterile and exhibit a range of flowering times. These will be tested at Canberra and other sites.

(ii) *Top Crossing between* P. tuberosa *Lines.*—Selected *P. tuberosa* lines are being topcrossed to tester plants of Australian commercial *Phalaris* and one introduction (C.P.I. 15022). Self-incompatible tester plants which have been isolated are being used in this programme.

(iii) *Polycross in* P. tuberosa.—Genotype-environment studies showed large genetic differences between plants of Australian commercial *Phalaris*. Forty-nine plants selected on the basis of winter production were polycrossed after clonal propagation. Progeny will be used to estimate general-combining ability.

(*d*) *Radiation Genetics.* — (i) *Root-knot Nematode Resistance in Tomatoes.*—First generation plants were screened for resistance to root-knot nematode (*Meloidogyne* spp.). Thirty-seven resistant mutants were selected from 6200 plants following ultraviolet irradiation of pollen, and one from 11,500 plants following X-irradiation of pollen.

Induced resistance appears due to a single dominant gene, with a resistance pattern similar to the *Mi* gene from *L. peruvianum.* More extensive tests are in progress to confirm these findings and to determine whether there are different genes for resistance.

(ii) *Host-rhizobium Interactions in Legumes.*—Second generation seed of a number of legumes for screening for altered host-rhizobium interactions has been produced.

(iii) *Beneficial Mutations in Subterranean Clover.*—Screening is being carried out of second generation plants of Tallarook subterranean clover for early flowering and other potentially desirable mutations.

(*e*) *Cytology and Cytogenetics.*—(i) Danthonia *spp.*—Cytotaxonomic studies on Australian *Danthonia* species and a series of F_1 hybrids indicate that the species are widely divergent. Speciation appears to have occurred by genic changes at the diploid level and by allopolyploidy following interspecific hybridization.

(ii) *Chromosome Races of* Themeda australis.—Collections from new areas have confirmed the pattern of chromosome races of $2n = 20$, 30, 40, 50, and 60 with geographical differentiation of the various races.

(iii) *Genome Analysis in* Phalaris.—The new hybrid *P. brachystachys* ($2n = 12$) $\times$ *P. minor* ($2n = 28$) forms rare bivalents at first metaphase. These may be due to autosyndesis or to allosyndesis involving either of the two genomes known to be present in *P. minor.* The univalents display neocentric activity and these may be the same chromosomes that show this activity in other *P. minor* hybrids.

(iv) *Autotetraploid Maize.*—Comparison of recombination fractions in autotetraploids and diploids, and the frequency of double reduction in tetraploids, indicated that recombination is more frequent in the centric regions of chromosomes in autotetraploids than in diploids.

(v) Hordeum bulbosum.—The production of awnless lines of *H. bulbosum* by hybridization with diploid and tetraploid awnless *H. vulgare* and by inducing awnless mutants was attempted.

Hybridization followed by embryo culture produced embryos which germinated, but all died shortly after germination.

(*f*) *Mathematical and Developmental Genetics.*—(i) Arabidopsis thaliana.—A thiamin-requiring mutant results from a genetic block operating in the pathway leading to the formation of 4-methyl-5β-(hydroxyethyl)-thiazole. The mutant has an unusual temperature sensitivity, in that it loses its requirement for thiamin as the temperature is increased.

It is possible in some cases to alleviate high temperature lesions by the application of media supplements to temperature sensitive strains. Studies of genetic homeostasis were made in 46 races, and in the parents and progeny of eight races with different temperature response curves.

(ii) *Recombination in the Tomato.*—Certain chemicals and graft stocks significantly decreased recombination. No treatment applied increased recombination. The amount of natural variation and the effect of age and position of flowers on recombination are being studied.

(iii) *Quantitative Inheritance and Theoretical Plant Breeding.*—Studies have been made on genotypic environment interactions in diallel crosses of tomatoes grown at different levels of nutrition.

As part of an overall study of general and specific combining ability, and the use of these in plant breeding, theoretical problems related to the identification of methods yielding unbiased estimates of population parameters have been studied.

(iv) *Trisomic Inheritance* (In co-operation with University of California, Davis).—A comparison is being made of recombination values obtained from trisomic and disomic individuals.

(*g*) *Pasture Plant Breeding.*—To define breeding objectives a range of ecotypes of seven species suitable for wheat belt pastures (*Dactylis glomerata, Ehrharta calycina, Hordeum bulbosum, Lolium multiflorum, L. perenne, Phalaris coerulescens,* and *P. tuberosa*) were grown as spaced plants in localities with 18, 21, and 25-in. annual rainfall. Assessments were made of productivity, flowering time, summer dormancy, and persistence.

4. GENERAL BOTANY.

(Division of Plant Industry.)

(*a*) *Structural Botany*.—Studies continued of the early ontogenetic development and histogenesis of monocotyledonous flowers. Examination is complete of *Juncus* spp. and *Luzula campestris* of the family Juncaceae. The general pattern of floral histogenesis in these species is comparable with that previously described for species belonging to the families Gramineae and Cyperaceae.

(*b*) *Taxonomy and Systematic Botany*.—A comprehensive index to Australian generic names has been completed under the title " A Dictionary of Australian Plant Names ". The preparation of the Australian genera of Leguminosae for the international Index Nomina Genericorum has also been made. An account of the native and introduced grasses of the Australian Capital Territory and a check-list of New England plants have been completed. These will provide useful hand-books for botanists working in the respective districts.

A revision of *Helichrysum* subgenus *Ozothamnus* has been completed and a new species of *Ixodia* described. A revision of the Australian species of *Psoralea*, and studies of the genera *Themeda*, *Nicotiana*, and *Hypoxis* are being undertaken.

Seeds of *Duboisia* and other plants were collected in northern New South Wales and south-eastern Queensland. Collections of seed of grasses and other native plants, including indigenous species of tobacco, are being made in the Kimberley region and other parts of north-western Australia.

5. MICROBIOLOGY.

(Division of Plant Industry.)

(*a*) *Phytopathology*.—(i) *Studies on the Phytoalexin Theory of Disease Reaction*.—It has been confirmed that temperature treatments of pods of *Phaseolus vulgaris* prior to inoculation with either *Sclerotinia fructicola* or *Botrytis cinerea* alters their clinical response to infection. The mechanism of this process is being investigated. Other host-parasite combinations are being used to study the biological activity in the host-parasite interaction chosen for this phase of the phytoalexin project. The purification and identification of the active component is being undertaken.

Crude phytoalexin diffusates from either bean or pea *S. fructicola* interactions can cause some inhibition of tobacco mosaic virus infection.

(ii) *Brown Rot Studies*.—Studies have continued on latent spore contamination of peach fruits. During the fruiting season in Canberra, the population of *S. fructicola* builds up gradually from a few early foci of infection provided conditions are favorable. Conidia of this pathogen are able to withstand extremes of temperature and humidity for long periods and remain viable. Correlation exists between wounding of the epidermal tissues of fruits and the subsequent development of brown rot.

(iii) *Studies on Sporulation of* Peronospora tabacina.—See Tobacco Investigations, Section 14 of this Chapter.

(iv) *The Physiology of Symptom Development in Plants*.—Studies on the physiology of symptom development in virus diseased plants are being continued.

(v) *Potato Leaf Roll Virus*.—Viruses which are transmitted from one susceptible host to another only by insects have in general defied isolation. In a study designed to purify potato leaf roll virus, extracts were prepared from infected *Physalis floridana plants*. Virus activity was demonstrated in these extracts by injection into aphids, and then allowing the aphids to feed on uninfected indicator plants. The virus activity may be lost from these extracts after approximately 2 hr. at 2° C., and the amount of virus-protein present is probably very small.

(b) Rhizobium *Investigations*. — (i) *Physiological Studies of Bacteroids*.—Suspensions of bacteria isolated from soybean nodules of various ages were used to establish patterns of change with time in respiration, nucleic acid content, and cell dry-weight.

(ii) *The Fine Structure of Nodules and Bacteroids*.—Electron microscope studies of thin sections of soybean nodules have shown fine filaments and granules in the nuclei of the bacteroids. These were enclosed in groups in the host cytoplasm by membranes which are thought to develop from the membrane which surrounds the original infection threads.

(iii) *Genetic Analysis of Symbiotic Variation in* Trifolium ambiguum.—Selection has been made for various nodulating characteristics. The nature of the inheritance is being analysed.

(iv) *Seasonal Changes in Nitrogen Fixation*.—The effect of season on nitrogen fixation was studied under controlled glass-house conditions. Summer-grown nodulated plants produced greater yields but fixed less nitrogen than plants grown in the autumn. Unnodulated plants supplied with combined nitrogen produced the same yields in summer and autumn but took up less nitrogen in the summer months.

(v) *Field Populations of* Rhizobium. — Population levels of *Rh. trifolii* in soils from natural pastures in the Armidale area, New South Wales, are determined by the clover species present. Populations were influenced by environmental factors only inasmuch as these influenced host plant populations.

(vi) *Stock Culture Collection*.—Effectiveness groupings of the genera *Lotus* and *Anthyllis* have been made. Strains effective on *L. corniculatus* were effective on *L. tetuis* and *L. arvensis*, but were ineffective on *L. ulginiosus*. *L. australis* together with *L. coccineus* fall within a third group and *L. maroccanus* in a fourth.

An anthocyanin-rich strain of barrel medic has been used in the rapid evaluation of the symbiotic effectiveness of *Rh. meliloti*, differences between plants nodulated by effective and ineffective strains being significant sixteen days after inoculation.

(vii) *Inoculation of Seed and Clover Establishment*.—Nodulation failure in certain areas of the New England region of New South Wales has previously been shown to be due to inoculation failure. Methods of giving the applied inoculum of nodule bacteria which is placed on the seed a greater advantage than it has using conventional methods are being investigated. A method has been devised for pelleting clover seed with a mixture of bentonite and organic material capable of supporting considerable multiplication of the inoculum during germination of the seed. In row trials in the New England region using pellets of this type, the percentage of plants nodulated was considerably improved.

Studies by the Plant Nutrition Section on the nodulation of legumes are reported in Section 7 (b) of this Chapter.

6. GENERAL CHEMISTRY.

(Division of Plant Industry.)

(a) *Soil Fertility*.—The effects have been studied of aerobic and anaerobic incubation, in the presence and absence of glucose, on the availability of relatively unavailable phosphates added to soil. Strengite ($FePO_4.2H_2O$) and native soil phosphate became more available following anaerobic incubation. This effect was sometimes increased when glucose was incubated with the soil. Rock phosphate and variscite ($AlPO_4.2H_2O$) were less available following anaerobic incubation, but these reductions in availability were prevented when glucose had been present.

These results are at variance with the generally accepted view that decomposing organic matter greatly increases the availability of iron and aluminium phosphates by producing organic acids which complex with the iron and aluminium to yield a release of phosphate.

(b) *Sulphur Availability.*—This investigation has been extended to a study of the carbon, nitrogen, sulphur, and phosphorus in a range of soils chosen to cover a wide variety of parent materials, climate, and topography, and included both cultivated and uncultivated soils. In the soils examined, a close relationship existed between carbon, nitrogen, and non-sulphate sulphur. Alkaline soils contained a slightly higher relative proportion of non-sulphate sulphur than did acid soils. Water soluble sulphate made up only a small proportion of the total sulphur in the majority of the soils examined.

In most soils, most of the sulphur appeared to be present in organic forms. Organic phosphorus, although correlated with carbon and nitrogen, showed wider variation than sulphur. The mean relative proportions of carbon: nitrogen: non-sulphate sulphur: organic phosphorus (C: N: S: P) were 150: 10: 1.26: 0.66.

(c) *Phosphorus Availability.*—The separation and identification of organic phosphorus compounds have continued from Australian soils. Initial investigations were confined to an examination of inositol phosphates with the use of paper and column chromatography and paper electrophoresis. The inositol phosphates, which may make up as much as 40 per cent. of the organic phosphorus in some overseas soils, are present only in small amounts in most of the soils examined to date.

(*d*) *Spectrochemical Investigations.*—An examination commenced of the applications of atomic absorption spectroscopic analysis to agricultural samples.

This method has several advantages over either flame or arc methods of emission analysis. The technique has been found to be well suited for the determination of zinc and magnesium in plant material.

For both, analysis is possible down to a concentration of 0.5 p.p.m. in solution, and they are detectable down to 0.1 p.p.m.

7. Plant Nutrition.

(Division of Plant Industry.)

(*a*) *Soil Fertility.*—Experiments continued to measure the effect of clover on the fertility of the soil and residual effects of phosphorus, sulphur, boron, and molybdenum. The first of a series of wheat crops has been harvested to measure changes in the soil fertility. Calcium nutrition of plants is being studied on some acid soils to determine whether calcium is deficient for the growth of legumes established without lime, or with lime pelleted seed, on these soils.

(*b*) *Nodulation of Legumes.*—Experiments in which calcium and hydrogen ions were varied independently showed that hydrogen ions have a dominant effect on the growth of *Rhizobium*. Calcium ions had no effect at any pH and were required at most in trace amounts.

There was a compound interaction between calcium and hydrogen ions in their effect on the nodulation of the clover plants. There are critical levels of calcium and pH below which each is essential for nodulation. Above these critical values almost maximum nodulation can be obtained by an increase in either calcium supply or pH. Under these conditions, each is replaceable by the other.

The growth of clover plants, when provided with combined nitrogen, was retarded only by extremely low calcium concentrations or excess hydrogen ions. The calcium requirement for nodulation of subterranean clover is higher than for growth of the host plant or for growth of *Rhizobium*. Chemical analysis of the plants showed that hydrogen ions depressed calcium uptake by the plants, which suggested that within the range of concentrations where increasing hydrogen and calcium are replaceable, the effects of calcium and hydrogen ions on nodulation are through their influence on the level of calcium in plants.

There appears to be a wide range of conditions with respect to calcium and hydrogen ion concentrations within which nodulation of subterranean clover is inhibited to a varying degree, but throughout which the growth of the plant is not affected, provided nitrogen is not deficient.

Also under conditions of extreme acidity or low calcium supply, clover would not grow well even if the plants were induced to form nodules.

Studies by the Microbiology Section on *Rhizobium* are reported in Section 5 (b) of this Chapter.

(*c*) *Role of Elements in Plants.*—The effect is being studied of nutrition on the changes that occur in the physiological and morphological characters of plants during development, together with the mechanism of nitrate reduction in pregerminal and young post-germinal embryos.

Sulphur metabolism experiments using short intervals of uptake of ^{35}S sulphate have indicated the earliest detectable product of ^{35}S sulphate reduction. Methods are being developed for the isolation of the compound for identification.

8. Mineral Nutrition of Plants.

(Division of Biochemistry and General Nutrition.)

Experiments have continued on the correction of minor-element deficiencies as they occur in the field. Study of the relationships between the concentrations of zinc in the plant as a whole and in its parts as development proceeds in environments where zinc is limiting has been completed.

The occurrence has been demonstrated of recognizable morphological changes in the developing leaves which supervene on zinc deficiency, and that do not become apparent in the intact plant until the affected leaves have expanded and begin to emerge. The findings explain the difficulties that have been experienced when attempts have been made to relate the concentration of zinc in the plant and its parts to the status of the plant as a whole, and will permit earlier recognition of zinc deficiency.

The amounts of zinc in the various parts of the plants have been estimated by direct microchemical procedures, and distribution at various stages has been determined by radioautographs of the organs of plants that had been provided with ^{65}Zn. These observations have shown conclusively the redistribution of zinc in the various organs during development.

Uptake of cobalt by subterranean clover from culture solutions containing ^{60}Co has also been studied. This plant readily absorbs cobalt ions from solution, which indicates that the failure of cobalt top-dressings to remain effective for more than a few months is due to fixation of cobalt within the soils.

9. Plant Physiology.

(Division of Plant Industry.)

(*a*) *Embryo Growth of Nutrition.*—In comparative studies of the growth and nitrogen assimilation of young excised embryos of *Anagallis arvensis* (Primulaceae) and of three cruciferous species, growth response to nitrate was slight or absent in all species. Response to nitrate was striking in the cruciferous species, though not in *Anagallis.* This responded well to ammonium salts and to urea, but in the cruciferous species the response was poor. All species responded vigorously to L-alanine, L-glutamic acid, and L-glutamine.

A nitrate reductase can readily be induced to high levels of activity both in immature and germinating wheat embryos. However, the enzyme cannot be functioning in the intact immature embryo.

(*b*) *Seed Germination.*—Investigations into the stimulation of the germination of seed of *Anagallis arvensis* by red light (6800 Å) and its inhibition by near infra-red (7200 Å) have been continued. Mixtures of red and infra-red, or alternate exposures to submaximal red and infra-red, resulted in an amount of germination which depended on the proportions of these. Temperature level and temperature alternations affect the ability of the seed to be stimulated by red light.

Evidence has been obtained that gibberellic acid can reinforce and substitute completely red light in its action on germination.

Two germination inhibitors extracted from *Echium planatagineum* have been distinguished by their behaviour on carbon columns and on paper chromatograms, and by their effect on germination of seed of a number of species.

(*c*) *Seedling Growth.*—Volume changes are being studied in successive leaf primordia and other structures at the shoot apex of wheat seedlings. These changes have now been linked with the weight changes already known for the first four leaves, the stems, and the roots. The change from dependence on seed reserves to dependence on the environment for raw materials is critical.

(*d*) *Nodulation in Legumes.*—Studies of the physiological mechanisms of root infection and nodule growth showed that clover roots exude tryptophan; that an auxin is produced when clover roots are cultured in the presence of nodule bacteria, but not in their absence; that this auxin has the same R_F value as indoleacetic acid (IAA) when chromatographed on paper in three-solvent systems; and that tryptophan hastens nodulation in lucerne roots.

(*e*) *Mechanism of Growth Regulator Action.* (i) *Role of Auxin in the Symptoms of a Physiological Disease.*—Changes occurring during the development of the symptoms of the physiological disease of tobacco, “ frenching ”, offered an opportunity for an assessment of the significance of extracted growth regulators in this condition.

In plant growth regulators from shoot tips of normal and frenched tobacco plants, the principal auxin, which had the same R_F value as IAA, was present in normal plants at four times the concentration present in frenched plants. From the known growth properties of IAA it was concluded that a deficiency of IAA could produce all of the “ frenching ” symptoms.

(ii) *A New Class of Antiauxin*—Cyclo*propane Derivatives.*—There are five requirements of chemical structure for auxin activity. Substances lacking one requirement only have been found to competitively inhibit auxin action, and thus are antiauxins. Three *cyclo*propane derivatives have been shown to be antiauxins and so introduce a new class of such substances.

(*f*) *Stage of Development and Digestibility in Pasture Plants* (in collaboration with the Wool Textile Research Laboratory, Melbourne). See Chapter XVI., Section 12.

Two pasture grasses and a clover were sampled at frequent intervals until late summer, and their digestibility estimated by a microbiological technique. Digestibility tended to remain constant during development, but considerable differences were found between the species.

(*g*) *Flowering in Long-day Plants.* (i) Anagallis arvensis.—The first leaf pair of this plant attained maximum sensitivity to long days when its area was about 10 mm². When the area reached 100 mm², approximately one-fifth of the final area, these leaves no longer initiated flowering.

(ii) Lolium temulentum.—Plant age has a marked effect on photoperiod sensitivity, and on the nature of the relation between the intensity of induction and the rate of inflorescence development.

(iii) Trifolium subterraneum.—The dark inhibitory process comprises at least two partial processes, affected by night length and night temperature respectively. A further inductive process is operative. This may be important in controlling flowering times in the field.

(iv) Themeda australis.—A pilot study is complete of the requirements of two strains of kangaroo grass for flower initiation. Both strains proved to be long-day plants with a response to cold treatment.

(v) *Gibberellic Acid.*—This acid reinforced the action of long days in *Anagallis arvensis*, but did not initiate flowers on its own. For *Echium plantagineum*, in normal days, the time to flowering was decreased.

(*h*) *Floral Differentiation.*—Various basal sterile speltoid wheats were subjected to a variety of environmental conditions before, at, and after inflorescence induction. Pronounced effects were found on the pattern of fertility of the basal florets.

(*i*) *Protein Synthesis and Developing Wheat Grains.*—The characterization of the development of the wheat grain is the immediate objective of this work. Techniques have been developed for the estimation of a number of nitrogenous substances, and biochemical assays for certain enzymes. The culture *in vitro* of isolated endosperms or whole ovaries has been attempted. In whole ovaries the embryos, but not the endosperms, showed development. These frequently grew into plantlets, emerging from the otherwise empty kernel.

10. BIOCHEMISTRY.

(Division of Plant Industry.)

(*a*) *Cell Growth and Differentiation.*—Problems of cell division, growth, and differentiation are being studied in isolated plant organs and tissues cultured aseptically.

(i) *Isolated Roots of Subterranean Clover.*—Studies are being made of factors affecting the growth of the main axis meristem in successive subcultures, initiation of lateral roots, the abrupt transition from newly initiated (slow growing) to fast growing laterals with accompanying increase in their capacity to grow in successive subcultures, and the influence of these processes on the growth form of the root system.

(ii) *Natural Cell Division Substances.*—In many instances, the induction of cell division requires the participation of an auxin and a kinin (e.g. kinetin, diphenyl urea). Thus, added IAA induces lateral root formation on a root axis, but considerable evidence suggests a requirement for a second substance, presumably a kinin. When auxin is added to isolated flax roots in which some lateral primordia are already present, the lateral primordia consequently induced form in the immediate vicinity of pre-existing primordia, which suggests that the latter may be centres of kinin production.

Diverse evidence has led to the formulation of the hypothesis that dividing cells produce cell division substances (kinins). This would explain a number of aspects of plant growth, e.g. the perpetuation of meristems. The hypothesis is being tested directly by preparing extracts from comparable dividing and non-dividing cells, and testing the extracts in tobacco pith or root pericycle systems. The presence of kinins in some tissues has been detected.

(*b*) *Studies of Tobacco Mosaic Virus* (*TMV*). (i) *Biosynthesis.*—Subcellular, particulate components of virus-infected tobacco leaf cells have been examined in order to investigate their possible contributions to virus synthesis. From studies of homogenates of leaves fractionated by centrifugation, it was concluded that chloroplasts contained virus.

The virus, as isolated from the chloroplasts, comprised 0.6-4.2 per cent. of the virus extractable from the leaf, and was indistinguishable from the virus isolated from the remainder of the leaf homogenate. However, *in vivo* studies with ^{14}C-aspartic acid supported the hypothesis that tobacco mosaic virus is synthesized, or that the nucleic acid and protein components are “ assembled ” within the chloroplasts.

Studies on the rate of incorporation of ^{14}C-aspartic acid into the soluble antigen of tobacco mosaic virus support the view that the soluble antigen is the precursor of the protein part of the virus.

Attempts to obtain incorporation of ^{14}C-aspartic acid into the virus, and into the soluble antigen, in cell-free preparations of leaf homogenates were unsuccessful.

(ii) *Ribonuleic Acid* (*RNA*) *Synthesis in Tobacco Leaves Infected with TMV.*—TMV-infected tobacco leaves were examined for the presence of polynucleotide phosphorylase. This enzyme catalyses the reversible polymerization of nucleoside diphosphates (such as adenosine diphosphate (ADP)) into long-chain, RNA-like polynucleotides. Whether it functions in RNA synthesis within the cell is still not clear. Experiments to date have failed to demonstrate any activity.

(iii) *Chromatography of TMV*.—It was reported previously that the chromatographic behaviour of TMV varied with different preparations. The behaviour appeared to be influenced by the state of aggregation of the virus. Molecular weight studies have shown that in the case of the heat-treated virus only is there any significant change in the state of aggregation.

The absorption of TMV on the "Celite"-cross-linked sulphonated polystyrene ("Cel-SPX") ion-exchange resin was found to be sharply dependent on the pH of the eluting buffer in the pH range 5.0-5.5. This agrees with the results found with a number of other proteins. This sharp dependence of elution behaviour on pH may be due to a configurational change in the virus molecule.

TMV which had been absorbed strongly on a column of the ion-exchange resin and then eluted was compared with virus which had not been absorbed on the column. The only significant difference was in their absorption spectra, and this difference occurred only in a few experiments. There was no significant difference in either molecular weight or biological activity.

(*c*) *Haemoglobin and Cytochromes of Soybean Root Nodules*.—Quantitative measurements of cytochrome concentrations carried out on the bacteroid and vegetative forms of "effective" and "ineffective" *Rhizobium* strains confirm the qualitative observations previously reported. When these organisms are grown vegetatively under lowered oxygen tensions the cytochrome *a* decreases in amount, but does not disappear, as in the "effective" bacteroids. The relation between these cytochrome changes and the terminal oxidase systems of *Rhizobium* are now being studied.

Some purification of a cytochrome *c* type pigment, one component of this oxidase system, has been achieved. When bacteroids are disrupted by a variety of mechanical procedures, 30 per cent. only of the total cytochrome *c* is released into solution. The insoluble cytochrome *c* is spectroscopically identical with the extracted pigment.

Spectroscopic and microscopic observations on the pellets obtained by centrifugal fractionation of the disrupted bacteroid suspensions suggest that most of the insoluble cytochrome *a* and *c* is present in the plasma membrane-cell wall fraction. A direct interaction may be possible between the extracellular leghaemoglobin and the bacterial cytochrome pigments. Attempts are being made to release the insoluble cytochromes by chemical and enzymic methods.

(*d*) *Oxidation of Inorganic Sulphur Compounds by Soil Microorganisms*.—Preliminary results on the extraction of a thiosulphate oxidizing enxyme and some cytochrome components from *Thiobacillus* X (*Thioparus*) were reported previously. The enzyme and three soluble cytochromes (cytochromes 550, 553.5, and 557 respectively) have now been separated from extracts and partly purified. The cytochromes all appear to be of the *c* type and have positive redox potentials of 0.15-0.21 V.

The thiosulphate oxidizing enzyme catalyses the oxidation of thiosulphate to tetrathionate, and also the reduction of cytochrome 553.5, which is in turn oxidized by a cyanide-sensitive system in a particulate fraction from *Thiobacillus* X.

Short-time incubation experiments with ^{35}S thiosulphate provided evidence that tetrathionate is the first product of thiosulphate oxidation by intact *Thiobacillus* X.

This aspect of the work is now complete. The pathway of oxidation of tetrathionate by thiobacilli is now being studied.

(*e*) *Conversion of Ferric Phosphate to Soluble Phosphate*.—Anaerobically decomposing clover tops in aqueous medium readily convert ferric phosphate to soluble phosphate, and can do so in the presence of iron and aluminium oxides. Phosphate in solution first increases and then decreases with time. This decrease is due in part to the formation of a phosphate which is soluble in acetic acid.

(*f*) *The Conversion of Manganese Oxide into Soluble Manganese by Plants*.—The availability of manganese not only depends on oxidation and reduction processes occurring in the soil itself, but is affected greatly by the plant. Availability to different plants is not related to the amounts of manganese oxide-reducing substances released from roots, but it may be related to the activity of these substances at the root-soil interface. In a manganese deficient soil from Penola, S.A., availability is limited either by the absolute amounts of oxide dissolved, or by the formation of an insoluble manganous complex.

11. BIOPHYSICS.

(Division of Plant Industry.)

(*a*) *Membrane Studies on* Nitella.—(i) *The Effect of Detergents*.—Dilute solutions of ionic detergents, when applied to *Nitella* cells, rapidly bring about their death. Microelectrode measurements of membrane resistance and potential difference indicate that the site of action of the detergent is the plasmalemma.

Survival time of the cell falls with decreasing ionic strength, increasing detergent concentration, and increasing hydrocarbon chain length; survival was much shorter in cationic than in anionic detergents. At high detergent concentrations survival time was constant.

(ii) *Electron Microscopy*.—An investigation is being made of the structure of the plasmalemma and other features of plant cell structure. In *Nitella* cells fixed with potassium permanganate, electron microscope pictures revealed a plasmalemma with the appearance typical of lipoprotein membranes.

(*b*) *Physico-chemical Studies*.—(i) *Tetrapyrrole Pigments*.—The spectra and basicity have been studied of a number of simple porphyrins (uro- copro-, and protoporhyrins as their methyl esters), solubilized in detergent solutions. Apparent pK values for the porphyrins have been determined. The spectra of the monocationic species of the porphyrins were determined in anionic detergent solutions, but no evidence was found for the existence of this species in either cationic or non-ionic detergent solutions.

(ii) *Phenoxy-type Acids*.—It is possible to evaluate H-acidity functions for concentrated solutions of hydrochloric acid, by using the spectroscopic change associated with the ionization of the strongly acidic phosphorus analogues of phenoxyacetic acid. It is possible in this system to compare the H, H_0, and activity functions under standard conditions.

(*c*) *Measurement of Injury in Plant Tissues*.—The low frequency-high frequency resistance ratio method of determining injury to plant tissue is being used to study cold hardiness of and drought injury to lucerne, and heat hardiness of *Phalaris* strains. This will serve as a guide in selecting parents and screening progeny in plant breeding programmes.

12. PLANT ECOLOGY.

(Division of Plant Industry.)

(*a*) *Rain-forest Ecology*.—Following the classification of rain-forests studies are being made of succession within particular communities. Particular emphasis is being paid to the regeneration of species such as hoop pine (*Araucaria cunninghamii*) which are of value to the timber industry. Field and laboratory studies are in progress to separate microclimate and edaphic factors in plant succession.

(*b*) *Alpine Ecology.*—Studies have continued of the relationship of summer grazing in relation to water catchment values. Small grazing experiments in the Kosciusko area have confirmed observational data previously reported. Soil loss and surface run-off studies support an earlier conclusion that a dense cover of grass is most suitable for the maximum infiltration of water. Evapotranspiration losses from alpine bogs are being studied. Instruments for these studies were designed by the Division of Meteorological Physics.

(*c*) *Ecology of Subalpine Grasslands.*—The first objective of this study, namely, the origin of the treeless grasslands of the subalpine areas, should be achieved this year. The effect of trees in modifying their own microclimate is under investigation.

(*d*) *Ecological Studies—Southern Tablelands of New South Wales.*—(i) *Vegetation Survey.*—The delimitation and classification of the plant communities on the Southern Tablelands has continued, and special emphasis has been given to the Yass River catchment, particularly the area south of Gundaroo.

(ii) *Autecology of* Bothriochloa ambigua.—This work has been completed.

(iii) *Microclimates and Topography.*—This work which will be continued at the new field station at Ginninderra is to be extended to a study of the effects of shelter-belts.

(iv) *The Distribution of Native Plant Communities in Relation to Soil Nutrient Status.*—Although soils of the *Eucalyptus polyanthemos* and *E. melliodora* communities differ in phosphorus status no evidence has been obtained that there is any relationship between soil phosphorus and the relative growth of the two species. Soils of *E. rossii* communities were found to be low in calcium. Subterranean clover grew poorly on such soils unless lime was added.

(*e*) *Vegetation Survey of the Macquarie Region, New South Wales.*—This work has been completed.

(*f*) *Arid Zone Ecology.*—A study of the degeneration of bladder saltbush (*Atriplex vesicaria*) communities under grazing has been commenced. Under heavy grazing *Atriplex vesicaria* is replaced by *Bassia* spp. and by grasses, principally *B. uniflora* and *Enneapogon avenaceus.*

Soil studies suggest that even where the saltbush cover is well preserved there is a mild soil stability associated with the arid climate. The instability of the soil is greatly increased by destruction of the saltbush under heavy stocking with sheep. Severely eroded soils have a strongly saline soil profile and are devoid of vegetation. The salinity pattern in saltbush stands suggests that saltbush takes up soluble salts in the 6-12 inch zone and through leaf shedding returns saline materials to the soil surface.

(*g*) *Ecological Studies on Weeds.*—(i) *Distribution of Introduced Plants in South-eastern Australia.*—A comparison was continued of the climatic range of introduced species in Australia and in overseas countries.

(ii) *The Biotic Factor and its Significance in Plant Succession and Weed Invasion.*—The effect of one species on another is being studied both at Canberra and in the rain-forests of southern Queensland. At Canberra one species has been found to affect the germination of another. *Danthonia* sp. plants at high densities were found to compete successfully with *Bothriochloa ambigua,* but at low densities they did not prevent invasion by the latter.

(iii) *Competition between Skeleton-weed* (Chondrilla juncea *L.*) *and Cereal Crops.*—The effect of skeleton-weed competition on the yield of wheat and oats was investigated, and nitrogen was found to be the major factor limiting yield. Fallow sprays which in 1956 reduced competition between skeleton-weed and cereals for nitrogen were ineffective under the dry conditions prevailing in 1957. The results point to the necessity of building up soil nitrogen levels on skeleton-weed infested land by rotations including legumes.

(iv) *Competition between Skeleton-weed and Pastures.*—Experiments are in progress at Cowra to determine the effects of competition by pastures on the subsequent growth of skeleton-weed and on the effect of the weed on succeeding creal crops.

(v) *Competition between Hoary Cress* (Cardaria draba) *and Wimmera Ryegrass* (Lolium rigidum).—The adverse competitive effects of ryegrass on hoary cress noted in the field are being examined in pot cultures.

(vi) Nasella trichotoma (*Yass River Tussock*).—The control of tussock by competition from pasture plants is being investigated. Particular attention is being paid to the factors controlling the establishment of pasture species on land not suitable for cultivation.

(vii) *Control of Thistles in Pastures.*—Studies have commenced on the autecology of a number of thistles which are weeds of pastures, particularly under conditions of high soil nitrogen.

(viii) *Control of Aquatic Weeds.*—Results obtained in 1956 which showed that applications of the ethyl ester of 2,4-D in 22 per cent. Diesel distillate were effective in controlling cumbungi (*Typha angustifolia*) in irrigation channels for periods of 4-5 months were again obtained. The importance of maintaining water levels at 2-2½ ft. depths subsequent to spraying was confirmed. Two applications of 2,4-D at 6 lb. per acre with maintenance of high water levels would give cheaper and more effective control than mechanical methods. Another method of control which appears to be more permanent than 2,4-D is the use of high rates of aminotriazole. The same treatment is effective for controlling *Paspalum distichum* (water couch).

(ix) *The Control of Eucalypt Regeneration in Fire-breaks.*—The control of eucalypt suckers following bulldozing of fire breaks has been achieved by spraying with " Ammate "; control is enhanced by addition of a wetting agent.

(x) *Mistletoe Control.*—Further work has been done in collaboration with the Forestry and Timber Bureau. Host tree susceptibility to injury by 2,4-D increases under drought conditions. Treatment in those circumstances cannot be recommended.

13. FRUIT INVESTIGATIONS.

(Division of Plant Industry.)

(*a*) *At Hobart.*—(i) *Physiology of Apple Fruits in Relation to Storage Disorders.*—Experiments continue on the effect of individual growth substances on cell division and size in fruits using the half-tree technique. Napthaleneacetic acid (NAA), kinetin, and adenine all increased cell number significantly. There was no significant difference between these three substances in the amount of increase; but the effect of NAA may be operating through a blossom thinning mechanism rather than by a direct stimulus to division. Unlike earlier experience there was some transfer of effect from the sprayed to the unsprayed halves of the trees.

Incidence of storage disorders was exceptionally low. Jonathan spot was the only disorder and a positive correlation between incidence and mean fruit size per tree was shown for the first time. Treatment with kinetin significantly increased incidence of this disorder. It was decreased by treatment with NAA, while adenine increased incidence but not significantly. These effects may be due to change in relative maturity.

Investigations of the effect on cell division of competition between fruitlets in the cell division stage using hand thinning methods indicated that increased cell division resulted when competition was reduced. This also reduced maturation rate, as measured by colour change and acid level, and incidence of Jonathan spot. Attempts to achieve a similar effect by chemical means were unsuccessful.

inconsistent results followed attempts to affect the nitrogen status of different parts of one tree.

(ii) *Apple Scald.*—Continuing trials have shown that wraps containing 1.5 mg. diphenylamine were still effective in controlling scald eighteen months after preparation. Preharvest spraying at 2,000 p.p.m. became ineffective two days after treatment, but the material could be applied simply and effectively as a post-harvest spray prior to packing. No other substances tried were as effective as diphenylamine.

(iii) *Maturation of Fruit in Relation to Climate.*—This study is part of a cooperative experiment with the States of Queensland, New South Wales, and Tasmania. In Tasmania the duration of higher temperatures may be the important factor, and apples may be more sensitive than expected to small differences in the diurnal high temperature range.

(iv) *Internal Atmosphere Composition in Relation to Fruit and Crop Size.*—Preliminary results from this investigation suggest that part of the higher susceptibility to disorders of light crop fruit may be associated with higher internal carbon dioxide concentration.

(*b*) *At Applethorpe, Queensland.*—(i) *Rootstock Investigations.*—In the twentieth year of the trial with East Malling stocks, Granny Smith trees on M.II. have yielded the heaviest crops followed by Spy, M.XII. and M.XVI. (equal), Pomme de Neige seedlings, and M.XIII. With the variety Jonathan the largest total crop has been produced by the largest trees on M.XII. stock.

The pruning and stock trial after nineteen years indicates that lightly pruned trees, with the use of the Weckers method, bears the heaviest crop. However, the larger Weckers-pruned trees, particularly Granny Smith, have failed to maintain growth.

The first crop from Merton stocks with Delicious scion indicated that Sky and 789 are stocks inducing early growth and heavy bearing. Trials with Merton-Malling stock, Jonathan scion, have given no indication of distribution between early or late crop inducing stock.

(ii) *Apple Physiology.*—The application of sprays of sugar and borax again allowed an earlier picking of the variety Jonathan. Previously observed early abscission of treated Granny Smith fruit did not occur. The physiological effects of these sprays are being determined.

Rate of fruit growth as measured by changes in weight, volume, starch content, total acid, total soluble solids, nitrogen content, and cell size is being studied to obtain an understanding of differences in keeping quality. The effect of rootstock on keeping quality is also being examined.

14. Tobacco Investigations.

(Division of Plant Industry.)

(*a*) *Canberra.*—(i) *Genetics.*—Experiments to transfer resistance to blue mould (*Peronospora tabacina*) from Australian species of *Nicotiana* to commercial varieties of *N. tabacum* were continued. Back-cross progeny have given a small proportion of resistant plants resembling flue cured tobacco in superficial characters.

Seeds have been treated with X-rays, gamma rays, thermal neutrons, and chemical mutagens, and pollen grains with X-rays and ultraviolet radiation. Screening of 35,000 first generation plants following mutagenic treatment did not reveal a dominant resistant mutant. Screening of 700,000 second generation plants from ultraviolet treatment of pollen, representing 1494 treated seeds or pollen grains, yielded some resistant plants. These, together with one spontaneous mutation from untreated seed of Virginia Gold, are being examined for disease susceptibility and other characteristics.

(ii) *Blue Mould* (Peronospora tabacina).—*Field surveys.*—Surveys were made of the incidence and distribution of blue mould in tobacco areas of Mareeba in Queensland, and Shepparton and Gunbower in Victoria. The looper moth (*Plusia argentifera*) may be a factor in the spread of the disease between fields.

Nutrition.—In field trials using four soil types and three levels of nitrogen, blue mould was less severe in plants making rapid early growth than on stunted slow-growing material. Studies on the role of nitrogen nutrition in disease incidence in large plants showed that total lesion and sporulation areas in leaves of plants without nitrogen were a significantly lower proportion of total leaf area than in plants with added nitrogen. Differences were correlated directly with leaf maturity as shown by leaf colour change.

Control.—Glass-house experiments have shown that blue mould in seedlings can be controlled by the use of benzol vapour even though infection has taken place.

Host-pathogen Relationships in Infected Tobacco Stems.—Studies of the origin and spread of stem infection in seedlings and field plants and the relationship between stem infection and survival of the pathogen between seasons have shown that some stem infected seedlings survive transplanting. Subsequent growth of the transplant is determined by the rate of growth of the pathogen in the stem.

Sporulation.—Sporulation is characterized by an optimal temperature of 19° C., a minimum temperature which is ill defined but in the vicinity of 2-5° C., and a maximum temperature of 26° C. The slope of the response curve is characteristic of the fungus and independent of age or condition of growth of the host plant. Absolute intensity of sporulation depends on the physiological state of the host plant, and is primarily a function of night temperature, but length and level of day temperature influence the final response.

Spore dissemination.—The pattern of spore dissemination in the field and glass-house is being investigated. Comparative spore numbers present per hour under varying conditions of temperature and moisture have been determined. Spore survival is being examined under different environmental conditions of dissemination.

(iii) *Leaf Structure and Quality.*—A study has been made of the anatomical structure of cured tobacco leaf of various commercial grades to ascertain the structural characteristics of the leaf responsible for the textural differences used in commercial grading. In tip grade leaves vein density was higher, cell size smaller, and the ratio dry weight to thickness higher than in all other grades. No significant differences occurred between other grades.

(*b*) *Tobacco Research Institute, Mareeba.*—The first crops grown at the Institute, as part of the plant breeding, biochemical, and nutrition studies, have been harvested. Thirteen small curing barns of approximately 250 leaves' capacity were constructed. These have been used for curing individual varieties from the plant breeding experiments and for preliminary studies of the biochemical and physiological aspects of curing.

(i) *Plant Breeding.*—A wide range of varieties was tested under local conditions for susceptibility of blue mould, growth, morphology, and curing behaviour. Of the varieties tested two Clayton hybrids and a *tabacum* x *debneyi* amphidoploid from Canada remained free of blue mould. A preliminary crossing programme based on these varieties was completed.

(ii) *Biochemistry.*—An examination of extraction procedures for non-starchy polysaccharides in green and cured tobacco has been made. Analytical methods for other soluble products, alkaloids, monosaccharides, and oligosaccharides from cured leaf are being studied.

(iii) *Plant Nutrition.*—Field trials have been established to investigate nitrogen relationships between soil and plant and to study the effect of nitrogen, phosphorus, and potassium fertilizers at different levels and in all combinations.

Experiments in the field and in sand cultures have shown that leaf known as "trashy" can be produced by unbalanced nutrition. Chemical analyses have shown the probable pathway of metabolism responsible for the production of this low-grade leaf.

15. PASTURE INVESTIGATIONS, CANBERRA.

(Division of Plant Industry.)

(*a*) *The Management and Utilization of Pastures.*—The pasture, the grazing animal, the soil, and other mutual relations are being studied from a number of viewpoints, all with the main objective of obtaining maximum production of animal units comparable with continued productivity of the pasture. The wide range of pastures and animal environments created by the experimental procedures offer scope for co-operative studies such as the genotype-environment interaction investigation currently being made with the Animal Genetics Section.

The current year was extremely dry and this provided an opportunity for studying the capacity of sown pastures to carry sheep and to persist under high rates of stocking and under different systems of utilization.

(i) *Conservation of Excess Pasture as Hay.*—This is a management system whereby the troughs in seasonal production of pastures may be overcome and wastage during peaks of production may be minimized. It involves heavy rates of stocking on part of a plot, field, or farm while the remainder is being conserved. The effect on the subsequent productivity of the cut and heavily grazed areas and on annual production is being investigated. Conservation enabled high rates of stocking—the major determinant of high annual production per acre—to be maintained during a severe drought. The use of conserved fodder in this way may be more important than using it for overcoming seasonal falls in production per head.

An examination of the separate factors of cutting and feeding back on both pasture and annuals showed that a *Phalaris tuberosa*-subterranean clover pasture cut for hay in 1955 and 1956, while not affected in these years, was markedly reduced in the 1957 drought year. Reductions in wool and lamb production were only partly counterbalanced by feeding back all of the material consumed by cutting in the two previous years.

(ii) *Crops for Supplementary Feeding of Animals.*—Another system of minimizing the effects of low pasture productivity in winter is to grow crops such as oats which are subsequently fed back. No gain in annual production can be expected from cropping; animals on pasture alone did better than those on which one-third of the area was devoted to crops.

(iii) *Use of Fertilizer Nitrogen for Increased Winter Production.*—The use of fertilizer nitrogen which promoted winter growth on grazed pastures to a slight extent in years of high and average rainfalls depressed production in the drought year of 1957.

(iv) *Increased Utilization of Dry Pastures by Spraying with Urea and Molasses.*—Such treatments appear to increase pasture utilization by inducing animals to be nonselective in their grazing, but in so doing may not necessarily increase animal production.

(v) *Special-purpose Pastures for Summer and Winter.*—To investigate the initial and subsequent capacities of individual species for dry matter production under grazing, four early-maturing and four late-maturing perennial grasses are being compared with *Phalaris tuberosa* for annual production and plant persistence under winter and summer grazing respectively. During the summer grazing period 1957-58, *Bromus inermis* and *Phalaris tuberosa* were superior to all other species under test. Liveweight gains on the *Bromus* pasture were slightly higher than on *Phalaris.*

The addition of other grasses to the usual simple mixture *Phalaris tuberosa*-subterranean clover did not influence the total annual production of dry matter but did increase production during dry seasons. The capacity of a species to sustain animal production is related to its ability to maintain its density either by reseeding or by tillering.

(vi) *Management of Pastures for the Breeding Ewe.*—Management of pastures are being studied to meet specific requirements of breeding ewes during pregnancy and lactation, together with the reciprocal effects of treatments on the subsequent productivity of pastures. Both perennial and annual pastures are included, and more detailed studies of the effects of treatments involving periods of stress on wool production by the ewe have been commenced.

(vii) *Estimation of the Intake of Grazing Animals.*—The use of faecal nitrogen is being studied for the estimation of the intake of grazing animals, including the relationships between percentage nitrogen in faecal organic matter and organic matter digestibility, and total faecal nitrogen and organic matter intake. Variations in these relationships due to season, age, type of animal, level of intake, and pregnancy will be investigated.

Seasonal changes in dry matter and nitrogen intake with pasture growth under grazing are being examined in a co-operative experiment with the School of Wool Technology, New South Wales University of Technology, and an attempt is being made to correlate such changes with wool growth and liveweight gains.

(b) *Other Pasture Investigations.* (i) *Soil Fertility Studies.*—Changes in fertility levels under sown pastures are being studied at Crookwell; such changes include cation-exchange capacity and phosphorus-sulphur-nitrogen relationships directly affected by the use of superphosphate.

The influence of a number of grasses and legumes on soil structure has been studied over a three-year period. The importance of soil fertility as a determinant of the species which can be grown satisfactorily in pastures has been demonstrated at Canberra, where the population density of perennial ryegrass has been markedly influenced by soil nitrogen levels.

(ii) *Crop-pasture Ley Investigations.*—Investigations continued on the possible use of annual species of *Medicago* as bases for temporary leys in the wheat belt. Data are available on the yield, persistence, effect on soil nitrogen, and palatability of a range of species and strains. A collection of 70 homozygous strains of barrel medic from overseas and Australia is being multiplied at Canberra. The nutritional requirements of barrel medic are being compared with those of subterranean clover as a possible aid to an understanding of their occurrence on different soils.

16. PASTURE INVESTIGATIONS, ARMIDALE.

(Division of Plant Industry.)

(*a*) *Pasture Ecology and Autecological Studies.*—The effect on native grass species of burning, plus defoliation, has been investigated over the past two years. Following a spring (September) burn, the effect of defoliation was to decrease the yield of all species compared with unburned defoliated plants. This effect was apparent, with minor exceptions, until the spring of the following year. Burning had a marked effect in decreasing soil moisture, and in the dry year of 1957 this effect was evident twelve months after burning.

In a study of the soil moisture pattern under native pasture large differences in available soil moisture were found to occur within areas of apparently similar soil type. These differences were reflected in the occurrence of different pasture types. Native sorghum-kangaroo grass pasture indicated a more favourable soil moisture pattern than two other pasture types studied.

(*b*) *Management and Utilization of Sown Pastures.*—Using a mowing technique, time, frequency, and intensity of defoliation of four pasture mixtures have shown little difference in subsequent productivity between the most severe and most lenient defoliation treatments. An exception to this was that a cocksfoot-clover pasture under severe defoliation showed a decline in subsequent productivity as defoliation was commenced later in the spring.

The low production of pastures during the winter months constitutes one of the limitations to increased animal production in the New England region. A range of annual species is being tested to determine the best species for increasing the amount of forage available during the winter months.

(*c*) *Improvement of Native Pastures.*—A comparison was made of different methods of sowing a range of grass species into a virtually pure stand of clover previously established by surface seeding. The success of establishment of the grasses was in the order combine, sod seeder, and broadcast methods of sowing. In another experiment, the yields of cocksfoot and tall fescue were greater where sowings were made with a sod seeder than where they were made with a disk drill.

Studies of the effects of burning native pastures before surface seeding with clovers have been inconclusive. In 1956 there was a slightly greater establishment of clover where native pasture was burned before sowing, but in 1957 establishment was higher where native pasture was not burned.

(*d*) *Plant Nutrition Studies.*—Critical phosphorus levels in soils are under investigation with the objective of determining the minimum level of phosphatic fertilizer necessary for adequate plant growth.

From a study of sulphur response curves of a wide range of soils, 24 soils were graded according to sulphur deficiency. Leached soils from the New England region showed the greatest deficiency, while a variety of soils including a krasnozem from Lismore, a red-brown earth from Griffith, a grey-brown soil of heavy texture from Deniliquin, and a brigalow soil from the Darling Downs showed the least deficiency.

Studies of decomposition of organic matter, with particular reference to the formation of ammonium and sulphate, have shown that mineralization of an element from organic matter depends not only on the proportion of that element in the organic matter, but also on the proportion of the other elements.

(e) *Clover Nodulation.*—One hundred and thirty naturalized strains of *Rhizobium* organism were collected and 50 of these tested. More than 20 per cent. proved more effective in nitrogen fixation than the standard strain used in commercial *Rhizobium* cultures. When testing is completed, the most effective strains will be further examined for resistance to the microbial antagonism which prevents nodulation of sowings of inoculated subterranean clover seed.

Prior application of fertilizers had no beneficial effect on the microbial antagonism as measured by the nodulation obtained in subsequent sowings of inoculated subterranean clover seed.

Although earlier attempts to improve nodulation by the use of lime, when applied in the drill row or in other ways, were unsuccessful, recent sowings of lime pelleted seed have shown an improvement in nodulation. The specific effect of the lime pellets and the effect of other seed coatings are being investigated further.

17. PASTURE INVESTIGATIONS, DENILIQUIN.

(Division of Plant Industry.)

(*a*) *Semi-arid Pastures.*—Population growth studies are now complete of *Danthonia caespitosa* in an eight-year grazing trial. The number of plants was not affected by changes of stocking rate from one sheep to 1.2 acres to one sheep to 2.4 acres. Climatic conditions determine the death and seedling establishment, and the population is dominated by plants of a single age group. The indifference of the pasture to district stocking rates suggests that extreme rates will be needed to force the grassland on these heavy clay soils to a further degenerative stage.

An experimental programme, based on present knowledge of the ecology of Riverina pastures, was commenced to develop methods of reducing the wide seasonal fluctuations in carrying capacity. Saltbushes (*Atriplex nummularia* and *A. vesicaria*) are being re-introduced into pastures where they have been eliminated by stock. The nutrition, water relations, and production of saltbush are being studied in a grazing trial. Lucerne varieties, *Phalaris tuberosa, Bromus* spp., and *Agropyron* spp. sown in rows at varying spacings are also being assessed.

(*b*) *Irrigated Pastures.*—Increased emergence of clovers on heavy soils has been obtained by the use of gypsum. Four field trials on methods of application were completed in the current irrigation season. A further trial has been commenced. Production of subterranean clover was increased from 1.8 tons dry matter per acre on the untreated to 2.6 tons by the use of gypsum, independent of the beneficial effect of the gypsum on emergence.

Trials to assess production, palatability, and persistence under cutting and grazing of 36 pasture species (21 legumes and fifteen grasses) have been satisfactorily established on both light and heavy soils. Trials have continued of lucerne strains with special reference to winter production. A promising variety (Hairy Peruvian) has been sown for seed multiplication and a further trial is in progress of its performance and persistence under a winter cutting programme.

Gross deficiencies of nitrogen and to a lesser extent phosphorus and sulphur have been demonstrated on a range of soil types. A number of problems have been found associated with nitrogen fixation in legumes. In many cases the legumes respond to applied nitrogen. Nitrogen fixation is poor even though nodulation with effective strains can be achieved. It is becoming evident that this problem limits production of many irrigated pastures. Studies of minor elements, seed pelleting, and inoculation are being made to solve this problem.

The role of fertilizer nitrogen, the rate of accumulation, and loss of nitrogen in the soil is being investigated with two summer crops, rice and a forage crop (Japanese millet).

The response of Japanese millet to applied nitrogen under grazing and cutting showed evidence of recycling of nitrogen under grazing. This trial is being continued to assess long-term effects of nitrogen application. The rice trial continues to show long-term effects on the soil and soil nitrogen.

(*c*) *Pasture Growth.*—Growth experiments on subterranean clover swards have shown that leaf distribution may be an important characteristic, as it determines the magnitude of stem respiration losses following defoliation. The distribution of leaves in depth, which varies with variety, has important effects on defoliation patterns and will influence the effects of grazing on varieties. The analysis of these effects will have important implications in grazing management.

18. AGRICULTURAL PHYSICS, DENILIQUIN.

(Division of Plant Industry.)

(i) *Simultaneous Transfer of Heat, Water, and Soluble Salts in Soils.*—The theory of this subject was elaborated; improved differential equations describing the simultaneous transport of water, heat, and salts were derived. These equations were applied to steady-state heat conduction in moist porous materials, thermal conductivity measurements with cylindrical probes (see below), and evaporation from dry soil.

Apparatus is now in operation for studying simultaneous transfer of heat and water under controlled conditions. Thermal conductivities and moisture characteristics of materials to be investigated were measured.

A detailed study was made of the measurements of thermal conductivity and moisture content with cylindrical probes. A theory of the method was enunciated and tested against laboratory experiments. This has led to an improved probe construction and to a better interpretation of experimental results.

(ii) *Climatic Differences between Irrigated and Non-irrigated Pastures, with Special Reference to the Influence of Advection.*—Measurements of climatic differences between irrigated and dry pastures during two seasons have been collated and analysed. This has led to the development of a physical theory for calculating the micro-climate of an irrigated pasture from meteorological data for the surrounding dry land, to a theoretical estimate of the potential evaporation rate for irrigated pasture and meteorological data for the surrounding dry land, and to a theoretical estimate of the potential evaporation rate for irrigated pastures.

19. PASTURE INVESTIGATIONS, WESTERN AUSTRALIA.

(Division of Plant Industry.)

(*a*) *Studies on Perennial Grasses.*—(i) Phalaris tuberosa.—Study is complete of the effects of nitrogen supply and extension of the growing season on four strains of *P. tuberosa.* The influence of initial plant density on yield and persistence is being examined when nitrogen is applied. Nitrogen had a small effect on persistence over the first summer, but density effects were very large. The relationship between root and top growth are also being studied. Attempts to increase, substantially, the production and carrying capacity of a *Phalaris* pasture by the application of heavy doses of nitrogen fertilizer (300 lb. nitrogen/acre) were not successful.

(ii) Hyparrhenia hirta.—Grazing trials of this grass indicate that it can withstand continuous grazing (two and two-thirds sheep/acre) and that its palatability compares with that of usual annual species. Previously observed marked differences in sheep body weights between *Hyparrhenia* and annual pasture were not repeated; sheep weights for the two pastures were similar throughout winter and summer periods. Abnormal summer conditions may account for this discrepancy.

Introduced species and strains of *Hyparrhenia* have been established in nursery rows. The characteristics of these introductions are being examined, including their tolerance to and growth rate under low winter temperatures.

(iii) *Other Studies.*—Experiments are complete at Kojonup and Perth in which the four grasses *Hyparrhenia hirta, Ehrharta calycina, Oryzopsis miliacea,* and *Phalaris tuberosa* were examined under intermittent grazing. *Phalaris tuberosa* was best of those tested at Kojonup, and *Hyparrhenia hirta* at Perth. The performance of *P. tuberosa* at Kojonup, even though relatively good, has not given any grounds for optimism regarding its future use.

Three perennial grasses were sown on each of five soil types at Kojonup. Yield data for *P. tuberosa* and cocksfoot (*Dactylis glomerata*) showed large intersite differences, and confirmed the reputed tolerance of cocksfoot to relatively infertile soils. Root profiles of *P. tuberosa* examined in auxiliary plots on four of the five soil types confirmed that rooting depth is shallow on two soil types, both important in the area.

(*b*) *Species and Strain Experiments with Annuals.*—(i) *Subterranean Clover.*—Experiments with strains grown under spaced and sward conditions have shown that seed production *per se*, though clearly important, is not the only factor involved in adaptation of strains to an environment. There is a minimal value for seed production for long-term persistence, above which seed yield is not important. Studies of strain adaptation in mixed swards have shown a broad relationship—relative frequency of strains is inversely related to maturity grading. Some strains of early-mid-season maturity persisted better than expected from this relationship.

Interelationships are being determined of strain and animal performance by using the three strains Dwalganup, Yarloop, and Bacchus Marsh. There were clearly defined differences in sheep body weight trends on the three pastures, Bacchus Marsh being superior to Yarloop, and Yarloop to Dwalganup.

(ii) *Brome Grasses.*—Grazing trials on mixtures of *Bromus* species were continued at a stocking rate of three sheep/acre. Some losses in body weight occurred during the summer. *B. carinatus* and *B. catharticus* have virtually disappeared after three seasons, but *B. trinii* and (especially) *B. mollis* are persisting satisfactorily. The volunteer ripgut brome (*B. rigidus*) has increased in density during the past two years.

(*c*) *Plant Nutrition.*—(i) *Phosphate.*—Comparison has been completed of the effect of annual superphosphate dressing and single initial dressing on a pasture grown for four years on both Kojonup sand and Boscabel lateritic soil followed by a cereal crop.

During the pasture phase total production was not affected by method of phosphate application. In the cereal year when all treatments were residual, annual dressings gave the higher yield. Annual applications were superior on the lateritic soil both for pasture and cereal. Phosphate analyses showed that very little applied phosphate was fixed in the organic form and that appreciable amounts were lost by leaching.

(ii) *Zinc.*—In a field experiment conducted over several years, there has been no clear relationship between weather conditions and zinc response in subterranean clover. Responses to zinc sulphate are inversely related to the concentration of zinc as an impurity in superphosphate.

(iii) *Chlorine.*—Of soil samples collected from 30 localities three were extremely low in chlorine content, and probably contain insufficient chlorine for healthy plant growth. These soils are being further examined in field and laboratory studies.

(iv) *Cation-exchange Capacity (C.E.C.) of Plant Roots.*—In cooperation with the Institute of Agriculture and University of Western Australia, an improved electrodialysis technique has been developed involving a minimum of damage to the plant tissue. The C.E.C. values for about 20 plant species were determined, and in general these fell into three groups: grasses, herbs, and legumes. With rock phosphate as a source of calcium and phosphorus for a number of plants, highly significant correlations were found between root C.E.C. and percentage calcium and phosphorus in the plant tops.

(*d*) *Ecology of Annual-type Pastures.*—At Kojonup the effects of a range of phosphate levels on yield and botanical composition are being studied under long-term intermittent grazing. There has been no indication of adverse effects of continued phosphate dressings on either yield or composition. Botanical composition on all phosphate-treated plots appears to have attained stability. In a second experiment using three sites, each under continuous grazing, no autumn soil-moisture stress was encountered. This is in contrast to the previous seasons. No distinct patterns of botanical composition change have emerged.

(*e*) *Soil Fertility.* (i) *Effect of Phosphate.*—Results from this work have been anomalous. In field studies the rate of soil nitrogen build-up was not clearly related to phosphate status (and yield) of the pasture; soil nitrogen accretion on very low phosphate treatment seemed unduly high. In contrast under pot-culture conditions, the soil type showed normal growth response and soil nitrogen build-up with increasing phosphate. In a further field experiment, large differences in clover production resulted from the phosphate treatments, but there was no significant net gain of soil nitrogen on any treatment.

(ii) *Short-term Build-up in Clover Pastures.*—In a study of the changes in soil fertility during the first five years of a subterranean clover pasture, which had been sown to wheat, both grain yield and total grain nitrogen were positively correlated with age of pasture up to the five-year maximum.

(iii) *Effect of Soil Type.*—Two soil types which previously had proved difficult for clover establishment have responded to lime and molybdenum. Annual increases of soil nitrogen are being maintained on six soil types. Rate of gain of soil nitrogen is positively correlated with the initial level of soil nitrogen.

(iv) *Restoration of Fertility.*—In a continuous cropping trial on virgin soil at Kojonup five years of cereal resulted in an almost complete depletion of available soil nitrogen. First-year clover pasture on this location showed seedling mortality symptoms similar to those experienced on " new land " in parts of the south-west. Symptoms were less severe where fewer crops have been taken. This work will be continued on " cropped out " land.

(v) *Pasture Management.*—No differences in soil nitrogen build-up were found between a grazed clover pasture, and clover pastures which were mown and the herbage either dehydrated and returned, or removed altogether; in all cases build-up was substantial, 85 lb. nitrogen/acre/year. The area was cropped to wheat to determine whether available soil nitrogen had been influenced. Differences between cereal yields were insignificant, and mean total nitrogen uptake for the three treatments ranged from 38 to 41 lb. nitrogen/acre.

(vi) *Urine-nitrogen Losses.*—Appreciable losses of nitrogen may have occurred from grazed pastures under trial. In assessment of urine-nitrogen losses from soil during summer months, as much as 48 per cent. of the nitrogen was unaccounted for. Losses during the growing season and the dry summer period are to be measured.

20. PASTURE INVESTIGATIONS, QUEENSLAND.

(Division of Plant Industry.)

(*a*) *Pasture Ecology.* (i) *Spear Grass Region.*—Drought seriously hampered investigations at Rodd's Bay, Brian Pastures, and Samford. Grazing of experimental sown pastures at Rodd's Bay continued at three times the normal stocking rate for native pastures up to the middle of 1957, but was then discontinued. The reaction of species to drought conditions was observed. All selected species survived, and following light rain in November, sown pastures made better growth responses than native pastures.

(ii) *Wallum Country.*—Information on suitable species and fertilizer treatments for pasture establishment on the wallum has been collected. The maintenance, management, and utilization of sown pastures under the grazing animal is now being investigated.

Despite an unfavourable season, sown pasture mixtures totalling 24 acres were successfully established for evaluation under grazing by cattle and sheep. Thirty-five acres of the total of 40 acres under experiments are now subject to regular grazing.

In the first year of a grazing experiment sheep were maintained throughout the year without supplementary feeding at an intensity of four to the acre, despite unfavourable seasonal conditions. Stocking intensities of a beast to the acre and a beast to 2 acres will be attempted on the new pastures established for cattle grazing experiments in the 1957-58 summer.

Among new pasture species established at Beerwah, pangola grass (*Digitaria decumbens*) and the African legume *Lotononis bainesii* have been outstanding.

(iii) *Brigalow Region.*—Rainfall below average enabled pasture species and mixtures to be evaluated under dry conditions. Strains of buffel grass and *Panicum coloratum*, and species of sorghum performed well, but strains of Rhodes grass were less drought resistant. Many grasses died out, especially strains of green panic and prairie grass. Lucerne continues to grow well but other *Medicago* species failed in the dry winter. Strains of the perennial legumes *Phaseolus atropurpureus, P. bracteatus,* and *Glycine javanica* have shown drought and frost resistance.

The performance of pasture species and mixtures is under study on further major soil types. New strains of Rhodes grass and *Panicum* have been established for evaluation under grazing.

(*b*) *Ecology.*—Detailed field studies commenced of the ecology of the subcoastal foothills of southern Queensland (spear grass region). This work is in areas immediately adjacent to the coastal lowlands which have been studied previously.

(*c*) *Legume Bacteriology.* (i) *Accumulation and Testing of* Rhizobium *Strains.*—Additions to the *Rhizobium* collection were chiefly tropical rain-forest species. Tests of nitrogen fixing ability were carried out with 97 strains of bacteria on the six legumes *Stylosanthes gracilis, S. sundaica, Leucaena glauca, Phaseolus lathyroides, Centrosema pubescens,* and lucerne. Yields and nitrogen contents of dry matter were measured and strains of *Rhizobium* were compared on the basis of milligrams of nitrogen fixed per plant. Large variations in nitrogen fixing ability were found in strains derived from *Phaseolus* and lucerne; variations were greatest for strains derived from lucerne.

(ii) *Calcium Nutrition of* Rhizobium.—It has been shown with a wide range of strains that the addition of calcium to yeast extract-mannitol agar is not necessary for growth and that calcium can have an inhibitory effect on slow-growing " cowpea "-type *Rhizobium*. These types make greatly improved growth when the agar is acidified.

Rhizobium from 48 strains, covering a wide cross section of the Leguminosae, have been grown for many generations in a synthetic medium containing no calcium. The growth of clovers in acid soils inhibitory to clover-type *Rhizobium* but where the acidity has been modified by calcium compounds and other bases is being studied. Magnesium was shown to be effective in promoting the growth of *Rhizobium* in acid soils.

(*d*) *Pasture Evaluation and Animal Nutrition.*—(i) *Subtropical Grasses.*—In studies carried out under pen feeding conditions with sheep, Western Australian buffel grass was more readily eaten than *Paspalum plicatulum* in winter, but not in summer. Some experimental animals refused to eat natural pasture in winter and very low intakes were general.

The decline in digestibility with increasing maturity was always less than the fall in intake. Differences in digestibility between sown pasture species at any particular feeding period were small but the digestibility of natural pastures was consistently lower.

(ii) *Feeding Standards.*—The use of accepted feeding standards to estimate requirements of starch equivalents and total digestible nutrients for sheep has been unsatisfactory. In most instances these standards over-estimated requirements under subtropical conditions. The most satisfactory criterion is dry matter intake, whilst digestibilty is generally less satisfactory.

(iii) *Supplementary Feeding.*—Over a 60-day period *Phaseolus mungo* grain and a mixture of urea, molasses, and ground corn cobs were fed on an equivalent nitrogen basis to different groups of wethers. The pulse supplement was slightly superior to the urea molasses supplement, both supplements reducing weight loss from 30 lb. per head to approximately 10 lb. per head, compared with unsupplemented control animals.

(iv) *Measurement of Grazing Intake.*—The relationship between herbage yields, liveweight increments, wool yield, and intake is being studied by grazing sheep on a pasture of *Paspalum scrobiculatum.* Intake is being measured indirectly by relating total faecal nitrogen to intake. Comparisons are being made with penned sheep fed cut grass from the same pasture.

(*e*) *Plant Breeding and Genetics.*—(i) Indigofera endecaphylla.—Crosses have been obtained between a short-lived, perennial, upland strain, non-stoloniferous and requiring well-drained conditions, and a perennial, lowland strain, strongly stoloniferous and thriving under poorly drained conditions. Experiments with mice, rabbits, and sheep indicate that β-nitropropionic acid is not the cause of toxicity in *Indigofera endecaphpylla*; identification of the toxin is proceeding.

(ii) Leucaena glauca.—Significant interstrain variation occurs in growth habit and production; strains from Peru and El Salvador are most vigorous and are being used as parental varieties in a crossing programme. Selection is being made for low content of the ruminant toxin mimosine.

(iii) Phaseolus.—Progeny from *P. lathyroides* x *P. semi-erectus* did not show resistance to root-knot nematode and *Phaseolus* virus 2. Strains of *Phaseolus atropurpureus* show persistence, ability to recover from grazing, and nematode resistance. Interstrain crosses have been made to combine desirable characteristics.

(iv) *Rhodes Grass.*—A study is being made in intra- and interstrain variation in characteristics, such as time of flowering, stolon development, frost tolerance, and persistence under grazing.

(v) *Lucerne.*—The production of adapted strains with a creeping rooted habit for use in sown pastures in brigalow country is being attempted. Crosses have been made with selected material from Australian, South American, and Indian sources.

(vi) *Apomixis.*—Means are being sought for inducing variation in apomitic species, such as *Paspalum dilatatum* and *P. scrobiculatum.*

(*f*) *Plant Chemistry.*—(i) Indigofera endecaphylla.—Aliphatic nitro compounds occurring in this species were identified. β-Nitroproprionic acid labelled with ^{14}C was synthesized for use in metabolism studies.

(ii) Leucaena glauca.—Observations on the metabolism of 5-hydroxypipecolic acid obtained from *L. glauca* leaves have suggested that it might be formed by the oxidation of pipecolic acid rather than from 8-hydroxylysine.

To assist in the development of strains of *Leucaena glauca* with low mimosine content, the colorimetric method of analysis of mimosine has been adapted for testing single plants.

(iii) *Analytical Techniques.*—Investigations were continued into the separation and quantitative determination of amino acids and amines in plants, by using ion exchange and paper chromatography. Good separation of the basic amino acids and certain diamines were effected but recoveries of some other amines were variable.

(g) *Plant Nutrition.*—(i) *Nutrient Status of Soils.*—Experiments to determine the optimum levels of fertilizer required to correct known deficiencies of potassium and phosphorus were established. Nutrient deficiencies of phosphorus, potassium, and molybdenum were found in sandy oil derived from granite at D'Aguilar. Responses to lime on this soil are believed to result from its effect on molybdenum availability. Studies are being made of plant responses to phosphorus and lime on heavy clay at Norwin, previously observed in pot trials, and the nutrient status of two soils at Samford. The nutrient status of brigalow soils from north of the tropic has been tested, and responses to sulphur and molybdenum have been obtained in pot experiments. The subsoil availability of these elements is being investigated.

Nutrition studies on pastures in the spear grass region were hampered by drought conditions; water became the limiting factor to growth. Nutrient requirements of pastures under grazing in the wallum country are being studied with particular attention to both legume and fertilizer nitrogen.

(ii) *Nutrition of Pasture Legumes.*—Glass-house studies were made to determine the relative responses to potassium of a number of summer growth pasture legumes. Plant material was analysed to determine the critical content of potassium associated with a deficiency for plant growth.

(iii) *The Productivity of Pastures Grasses.*—The relationship is being evaluated between the supply of available nitrogen and water, and the growth of pasture grasses. At Samford the application of nitrogen to sown pastures pastures receiving adequate quantities of other elements showed this element to be the chief limiting nutrient. Experiments carried out during the dry early summer of 1957-58 indicated that even under unfavourable conditions, dry matter production can be increased three- and fourfold by adequate nitrogen nutrition. Differences are being studied between grass species in their reaction to variations of nitrogen nutrition and water supply.

(iv) *Nitrogen Fixation by Pasture Legumes.*—The rates of nitrogen fixation by selected tropical legumes are being measured and compared with those of two temperate species of proven efficiency—Hunter River lucerne and Ladino white clover. Of the tropical species *Lotononis bainesii* and *Indigofera endecaphylla* were outstanding.

Experiments tracing the changes in nitrogen fixation occurring when plants of *Phaseolus lathyroides* are stunted by drought indicate that the effects of drought are exerted primarily on the host plant rather than the nitrogen fixing microorganisms.

(*h*) *Plant Physiology.*—To obtain an understanding of the characteristic occurrence of putrescine in potassium deficiency, radioactive tracer techniques are being used to investigate pathways of putrescine metabolism. Radioactive putrescine is formed in potassium deficient barley during the metabolism of DL-ornithine-$2^{14}C$; a few milligrams of ^{14}C-putrescine have been synthesized and preliminary feeding has been carried out. The amine is readily utilized by normal plants.

The initial chromatographic evidence of the occurrence of ornithine in higher plants has been confirmed.

21. FODDER CONSERVATION.

(Fodder Conservation Section.)

Drought and near-drought conditions in many regions during the past year have emphasized the importance of fodder conservation to the agricultural economy. Not only is a more extensive use of conservation on the farm a matter of urgency, but equally important is the need to improve present techniques, in order to reduce the enormous wastage of effort and materials which so often occurs. In recent years, the availability of improved and cheaper machinery has greatly reduced the labour involved in conserving fodder crops. Much, however, remains to be learned of the basic principles of ensilage and haymaking.

(*a*) *Haymaking.*—(i) *Field Trials.*—Two urgent problems of haymaking are to minimize mechanical losses, and to achieve rapid curing, thereby limiting chemical changes which lead to reduced nutritional values. Further trials have been carried out with ryegrass-clover pastures to determine the best stage of drying in the swath before breaking into windrows. Early raking retards the initial drying and increases the respiratory losses, while prolonged drying in the swath increases fragility and leads to excessive mechanical losses. It may be possible to define intermediate stages for raking at which both types of loss would be minimized. Conventional haymaking is too expensive, especially when storage and subsequent hand-feeding are costed. To reduce these changes the possibility is being explored of leaving hay in the field either in bales, small stacks, windrows, or even as standing pasture.

Most of these field experiments have been carried out at the State Research Farm, Werribee, and the co-operation of personnel there is greatly appreciated.

(ii) *Chemical Investigations.*—The development has continued of improved analytical methods and their application to examination of the chemical characteristics of fodders conserved by various methods. Particular attention has been given to soluble carbohydrates and nitrogenous constituents. A new rapid procedure has been devised for extraction of lipids from fodders.

Effects of storage conditions on the chemical changes occurring in hay have been investigated. These changes may be much more extensive than is generally believed. Detailed qualitative and quantitative studies have been made of the changing pattern of soluble sugars related to the stage of maturity of ryegrass when harvested. Chemical studies have also been made of losses caused by respiration during the curing of hay.

(iii) *Physical Investigations.*—Investigation has continued of the drying characteristics of pasture plants as affected by air velocity, humidity, and temperature. Experiments involving prior crushing of clover and lucerne plants have indicated beneficial effects on rate and uniformity of drying. Fragility of hay crops and the related susceptibility of leaf loss during curing have been found to be affected by both growing conditions and curing methods. Trials have been initiated with chemical desiccants as aids to hay drying.

The respiratory drift during curing of pasture plants and the losses of dry matter which occur have been studied in some detail.

(*b*) *Ensilage.*—(i) *Laboratory Trials.*—Studies have continued on the beneficial effects on wilting on the ensilage of ryegrass. A new series of experiments has been commenced to determine interrelationships between ensilage performance, plant maturity, and ensilage temperature. Closed system silage trials, on a miniature scale, have been carried out to obtain more detailed information regarding dry matter and nitrogen losses. Ensilage of lucerne, with and without addition of molasses or sodium metabisulphite, has shown that effects of these additives are markedly affected by the prevailing temperature; higher temperatures render them less effective in reducing losses.

(ii) *Microbiology of Ensilage.*—Work has continued on the characterization of lactic acid bacteria isolated from various laboratory silages. In addition, the growth of selected strains has been studied in artificial media and in the juice of ryegrass harvested at several maturity stages. Moisture content has been found to exert a profound effect on bacterial development in silage made from ryegrass wilted to varying degrees.

(iii) *Biochemistry of Ensilage.*—Changes and losses of nitrogenous material in silage are being investigated. Following completion of a preliminary exploration of nitrogen redistribution during wilting and ensilage of ryegrass and clover, more detailed enzymological studies have been undertaken. Initial work is concerned with properties of the proteolytic system of juice expressed from clover plants.

IV. IRRIGATION.

1. GENERAL.

With rare exceptions, experience throughout the world has shown that the fertility of irrigated land is very difficult to maintain for extended periods. The continued application of water to the soil can result in problems not encountered in dry-land agriculture.

The Organization has two Irrigation Research Stations for studying the ways in which irrigated land can be made to keep its fertility, and the techniques which can be used to reclaim waterlogged or salted soil. These are: the Commonwealth Research Station (Murray Irrigation Areas) at Merbein, Victoria, and the Irrigation Research Station (Murrumbidgee Irrigation Areas) at Griffith, New South Wales. The work of these two stations is reported in this chapter.

Research into soils and their behaviour under irrigation has been carried out at both Merbein and Griffith in close co-operation with the Division of Soils (see Chapter II.).

Studies of irrigated pastures are carried out at Deniliquin, New South Wales, by the Division of Plant Industry (see Chapter III., Section 17), and other investigations of irrigation techniques for northern tropical areas are performed by the Division of Land Research and Regional Survey at the Kimberley Research Station near Wyndham, Western Australia (see Chapter XI., Section 3). Work on dried vine fruits in progress at the Commonwealth Research Station, Merbein, Victoria, is reported in Chapter XIII., Section 13.

Irrigation Research Stations.—The research programmes have continued without major change, the emphasis both at Merbein and Griffith being maintained on problems of fertility retention and reclamation of water-logged or salted land.

Mr. E. R. Hoare has taken up the position of Officer-in-charge at Griffith (see Chapter I., Section 4).

A notable new piece of equipment acquired at Merbein during the year is a drilling rig capable of boring by percussion to a depth of 800 ft. or of rotary drilling to lesser depths, with borehole pumps for testing discharge from bores. At Griffith, the Home Farm has been tile drained and a portion will be used for studies of plant and soil reclamation.

As more information is being obtained on the distribution and behaviour of the plant pest nematodes, it is becoming obvious that their importance has been underrated. During the year, Merbein Station organized a conference which was attended by nematologists from the Victorian Department of Agriculture and the University of Adelaide. The conference resulted in a stimulus to the research programmes at each of these centres.

The Water Conservation and Irrigation Commission of New South Wales continues to make annual contributions to funds of the Griffith Station. In the Murrumbidgee Irrigation Areas and elsewhere, co-operative work is done with officers of the Commission, especially on groundwater problems.

The New South Wales Department of Agriculture is co-operating in the Murrumbidgee Irrigation Areas in studies of ion chlorosis control and of effects of waterlogging and salting on nutrition of apricots and peaches.

2. MERBEIN.

(*a*) *Irrigation, Soil Preservation, and Reclamation.*—Observations have been continued of levels of groundwater in piezometers and test wells in Renmark, Swan Hill, and Wakool districts.

In tile drain studies, the volume of air trapped below a temporary water-table has been measured. In some cases sufficient air was present to produce compressible flow conditions about piezometers, and an approximate method was necessary in calculation of *in situ* permeabilities. When relating drain discharge to field conditions, it was found that for the two soils investigated best agreement was obtained when the soils were considered as two horizontal layers. Also it was best to use harmonic rather than arithmetic means of *in situ* permeabilities when taking into account series resistance to flow through successive soil segments.

In studies of use of water by vines, chloride and water were extracted by pressure membrane apparatus at tensions up to 6 atmospheres. Negative absorption of chloride was observed. The unsaturated permeabilities calculated from rates of moisture extraction were lower than those necessary to give rates of water movement calculated from chloride changes in the field.

A neutron-scattering moisture meter is being calibrated against gravimetric determinations to follow soil moisture changes in an irrigated sultana vineyard.

(*b*) *Horticulture*.—Microscopical examination of sultana buds in May, 1957, allowed a forecast of 35-36 cwt. per acre of dried fruit. Based on this figure, Department of Agriculture officers recommended that growers prune their vines to the usual number of buds. Latest figures, which are almost complete, for the crop harvested in autumn 1958 show an average of 35 cwt. per acre was realized. A potential crop of 38 cwt. per acre is forecast for 1959, based on the very high potential fruitfulness of 70 per cent. of buds.

Refinements in the crop forecasting technique are under examination. Commencing mid March, 1958, buds were forced at 20° C. and, at the point of bud burst, the bunch primordia weighed. Experience will be required over several seasons to assess the value of this technique. Statistical examination of records reveals that a very similar forecast will result from examination of buds at positions 4, 9, and 14, instead of all 14 buds.

A forecast of 68.2 per cent. fruitfulness in sultana buds, based on relation between fruitfulness and hours of bright sunshine in spring, was made in December, 1957. This compares with the fruitfulness of 70.1 per cent. obtained from microscopical examinations of buds in May, 1958, and mentioned above.

Three aspects of the effect of sunshine on fruitfulness are under investigation—light intensity, light duration, and location of light perception. Single buds in the field covered with aluminium foil from 24th October to 27th November were significantly reduced in fruitfulness, while covering from 13th to 26th November had no effect.

Reduction in bunch number per vine obtained either by reducing the number of canes or by disbunching gave similar reductions in yield of fruit for the second successive year. Disbunching had no effect on subsequent fruitfulness.

" Cutting out " of sultana canes was done during maturation of the grapes, as is usually done during pruning. This drastic treatment had no ill effects on bud burst, yield, or maturity of fruit in the season following.

Buds from canes, taken from unpruned vines in the field after the date when dormancy was broken and cut into single bud cuttings, were kept at 20° C. Buds burst simultaneously at all bud positions from 3 to 14. On cuttings taken and similarly treated some time after pruning to 14 buds, terminal buds burst first and basal buds last, as is usual with bud burst in the field, showing that the correlative inhibitions must be set up some time before natural bud burst.

Attempted control of the weed " hardhead " (*Centaurea picris*) in the vineyard with C.M.U. resulted in severe damage with premature leaf fall and prevention of maturation of fruit and wood.

(*c*) *Plant Nutrients*.—It is thought that spring sunshine affects fruitfulness of sultanas by affecting carbon/nitrogen ratio. High, medium, and low soil nitrogen in spring, first applied in 1956, did not affect 1957 harvest. At 1958 harvest, low spring nitrogen gave a significant increase of 37 per cent. more bunches and 26 per cent. more fresh fruit over high nitrogen, and yielded 41.5 cwt. per acre of dried fruit compared with 35.0 cwt.

Sultana buds show a significant increase in moisture content at the time when they are changing from organic to induced dormancy. It is thought that winter uptake of nitrogen occurs soon after this change. Temperature and rainfall for a 19-day period in winter can be related to sultana yields over the years 1947 to 1957 inclusive. These are factors which influence soil nitrate level.

Because long-continued investigations of the nutrient requirements of the sultana vine in the fields have provided variable results, the emphasis is being changed from field trials to nutrient solution cultures. It has been possible to grow vines much more quickly than in the field and thus produce differential results in a shorter time.

(*d*) *Vegetables*.—Tomato varieties Merbein Early and Merbein Mid-Season, bred by the Station and the Division of Plant Industry for resistance to root-knot nematodes and fusarium wilt fungus, have been released to Departments of Agriculture and selected seedsmen for further trial. These two hybrids have high yielding capacity and good agronomic qualities. A third variety, Merbein Canner, an excellent canning type, will be tried on a commercial scale by a cannery in the Murrumbidgee Irrigation Areas in the coming season. Three new nematode resistant lines were received from Hawaii Experiment Station and single plant selections were made for resistance and agronomic qualities.

A programme of selection of glass-house tomatoes for resistance to root-knot nematode, fusarium wilt, and leaf mould, has been continued.

The Division of Plant Industry is co-operating in mutation genetics studies (see Chapter III., Section 3). Pollen of four tomato varieties were irradiated with X-rays and ultraviolet rays to produce 44,000 seeds which, in nematode infested seed-beds, gave 18,000 plants. From these, 200 which were free of attack were transplanted into infected soil. At maturity, seed was obtained from 40 plants showing little or no attack for further genetic studies.

(*e*) *Nematology*.—In the seventh year of a soil management trial at Red Cliffs, a breakdown of resistance in all plots of the tomato hybrid H.E.S.4242 was observed. This result was not correlated with an unidentified root-rot fungus, which disproved any possible interaction.

Grapevine rootstocks resistant to nematodes have been imported and are being held in quarantine. When released, these and seven phylloxera-resistant rootstocks already held by this Station will be tested for nematode resistance in this environment. Numbers of nematode larvae and eggs were not correlated in monthly counts made on heavily infested soil fallowed in summer, which made it impossible to forecast the root-knot potential of arable land. Two new species of the genus *Hemicyclophora* were discovered in uncleared Mallee soil in the Hattah area.

Soil fumigation trials with " Nemagon " (1,2 dibromo-3-chloropropane), " Vapam " (sodium *N*-methyl dithiocarbamate), and EDB (ethylene dibromide) gave better yields of tomatoes with heavier dosages of fumigant. Sultana cuttings were irradiated with ^{60}Co to induce mutations, and will be tested for resistance in nematode infested soil. Pathenogenicity to grapevines of lesser known nematodes such as pin nematodes, as well as citrus nematodes, is being investigated.

Studies of the structure and chemical composition of cuticle and egg sac of the genus *Meloidogyne* have been completed. The egg sac consists, in the early stages, of a glycoprotein made up of at least fourteen amino acids while the protein of the cuticle is made up of at least fifteen amino acids. Both egg sac and cuticle can be classed as secreted collagens.

The growth curve of the female *M. javanica* is sigmoidal with a plateau corresponding with the moult period. Under optimal conditions moulting was first observed on the fourteenth day and egg sac formation on the twenty-seventh day. Egg laying began two days later. The pre- and post-moult stylet sizes and excretory pore positions showed marked differences. The hypodermis thickened just before onset of moulting.

Advantage has been taken of the unusual metamorphosis of this nematode to watch the development of a male in a perfusion slide *in vitro*.

Histological examination using various microscopical techniques before, during, and after moulting has been carried out by using living specimens, whole stained specimens, and stained sections.

(*f*) *Dried Fruits.*—The work of the Commonwealth Research Station, Merbein, on dried fruits is reported in Chapter XIII., Section 13.

3. GRIFFITH.

(*a*) *Soil Chemistry.*—The factorial citrus experiment on Farm 466 is being used for soil as well as horticultural studies. This experiment involves Valencia and Washington Navel oranges each on two rootstocks with four cultural treatments and four levels of ammonium sulphate, with and without the addition of lime.

Sulphate of ammonia fertilizer reduced exchangeable potassium as well as exchangeable calcium and magnesium. Potassium loses were, however, less severe than those of the divalent ions. Soil from tillage plots receiving superphosphate contained less exchangeable magnesium than from non-tillage plots receiving no superphosphate.

(*b*) *Horticulture.*—The marked improvement in fruit quality in the no-tillage treatment on Farm 466 after the application of superphosphate, which was first reported last year, has been continued. Increasing levels of nitrogen supply, however, caused a decline in fruit quality but cultural treatments had no effect at each nitrogen level.

Superphosphate also improved yields in the grass sod treatment. At the no-nitrogen level, establishment of a clover sward apparently improved the nitrogen supply and consequently appearance and yield of trees. With ample nitrogen, yields improved until these were equivalent to those of the tilled treatments. The bare surface treatment with ample nitrogen tended to regain its superiority in yield held in the first two years of the experiment (1947-49).

Applications of farmyard manure have been discontinued, as they have had no effect, and *Trifolium subterraneum*—the early-seeding Yarloop strain—has replaced tick beans (*Vicia faba*) as the green manure in these plots. Cultivations in this treatment will be limited to make it a semi-sod culture.

The depressing effect of increasing nitrogen supply on fruit quality is being studied in the glass-house with the use of rooted navel orange cuttings in sand cultures, with varying nitrogen and phosphate levels.

Topsoil from two cultural treatments at three ammonium sulphate levels was used in glass-house trials to study the after-effects of ammonium sulphate on the soil (other than nitrogen supply). Ammonium nitrate was added to duplicate levels of nitrogen and ammonium found in the field, and orange seedlings were grown in the pots. Dry matter production and phosphorus uptake decreased with increasing field nitrogen levels; but in both for dry matter production and phosphorus uptake, phosphorus gave a far greater response when applied to soil having no nitrogen additions.

(*c*) *Plant Physiology.*—(i) *Plant Water Relations.*—Studies have been continued to assess the effects of moisture stress on the key compounds in the metabolism of the plant which are associated with cell division and protein formation. In studies on the lupin at Oxford, cell division appeared to be impaired and primordia formation prevented even at incipient moisture stress when the plant exhibited no external signs of moisture stress.

These studies were continued at the California Institute of Technology where whole young tomato plants were subjected to a single period of moisture stress. The effects of this whole-plant treatment were considered on laminae alone. Net synthesis of ribonucleic acid (RNA) was blocked in the moisture stressed plants. ^{32}P-labelled phosphorus was rapidly incorporated into leaves of moisture stressed plants, which indicated that the block to net accumulation of RNA was not a block in ability to synthesize RNA. On the contrary, two kinds of evidence suggest that there was accelerated destruction of RNA.

The first piece of evidence is that when a pulse of ^{32}P is supplied to plants at the beginning of a moisture stress cycle, the ^{32}P is rapidly incorporated into RNA. In the control (non-stressed plants), the labelled RNA remains in the leaf although it is diluted by further unlabelled RNA. In moisture stressed plants, on the contrary, labelled RNA is degraded, at least in the first few days after treatment, although net RNA remains constant in amount.

The second piece of evidence which bears upon the matter is that obtained from leaves incubated in solutions of varying osmotic concentration. It is apparent that sufficiently high osmotic stress causes leaves to lose RNA more rapidly than they otherwise would, although they retain the ability to incorporate labelled phosphate into RNA and hence presumably to synthesize RNA.

(ii) *Salt Intake.*—Salinity effects on plant growth are under investigation, barley being used as the test crop. When salts were removed, after a brief salinity treatment of the substrate, plants treated with calcium chloride recovered less than plants treated with sodium chloride. Chloride retranslocation of these two different salt treatments was essentially similar. Five days after salt removal the roots were largely depleted of chloride previously absorbed, while no appreciable amounts of chloride were retranslocated from the older leaves.

(iii) *Plant Nutrition.*—Control measures for lime-induced iron chlorosis, a widespread trace element disorder of peaches and apricots in the Mirrool irrigation area, have been tested, some in cooperation with the New South Wales Department of Agriculture. The most promising treatment for severe chlorosis was a trunk injection technique using ferric citrate, but it is not a satisfactory treatment for young trees or where large areas of trees are involved. A new iron chelate as a foliage spray is the most promising treatment for mild and transient chlorosis.

The physiological nature of iron chlorosis will need to be better understood before effective treatments can be designed. Macronutrient data indicate a boosting of potassium levels in leaves of chlorotic trees.

Analyses of leaf samples from commercial peach and apricot plantings were made over the last two seasons to obtain nutritional data as a basis for long-term studies on drainage, salting, and mineral nutrient effects. The elements potassium, phosphorus, calcium, magnesium, sodium, and chlorine have been determined. Potassium levels were usually considerably reduced with increasing water damage, and this effect was more marked when interactions between the crop and leaf potassium levels were taken into account. Other nutrient levels were often similarly affected with the exception of phosphorus which was commonly at an abnormally high level in damaged trees. Little or no salting was observed in these samples. However, serious salting was observed on a number of peach plantings with leaf chloride content from affected trees of 1-3 per cent. compared with a normal 0.1 per cent. The balancing cation within the leaf has in general not been sodium.

Analyses indicate that the poorer performance of apricots on plum than on apricot stock is due to lowered ability to accumulate a sufficient level of potassium in the leaves, despite better ability to withstand waterlogging.

Softwood cuttings from Golden Queen and from sucker growth of peach seedling rootstock were successfully struck in a small intermittent mist propagation frame by using an East Malling type electronic " leaf " device.

(*d*) *Entomology.*—Red scale (*Aonidiella aurantii*) is by far the most important pest of citrus in Australia and field control is far from satisfactory. High natural mortality has been observed during heat waves, so heat treatments ranging from 50-70° C. were given for varying times, freshly picked Washington Navel fruits parasitized with red scale being used.

All time/mortality curves were sigmoidal and similar to dosage/mortality curves normally obtained in entomological control studies. Reliable 100 per cent. " kills " were obtained for treatment periods ranging from 1 hour at 70° C. to 2½ hours at 50° C. Raising humidity from 11 to 40 per cent. did not alter mortality rates, which suggest a temperature rather than a dehydration effect.

(*e*) *Land Drainage.*—Studies of physical behaviour of installed drainage systems have been completed, and laboratory and field data analysed and compared with theoretical solutions. A comprehensive account of the data collected is in course of preparation, as an addendum to a paper already submitted for publication.

Variations of soil anisotropy which were previously reported have been investigated by determining anisotropy ratios in the field on a number of large wells and by taking core samples for direct determination of the horizontal and vertical components of hydraulic conductivity in the laboratory. Further analytical and experimental work is necessary.

V. ANIMAL HEALTH AND PRODUCTION.

1. GENERAL.

Although Australia's manufacturing industries have grown substantially in the post-war years, live-stock still make a major contribution to the nation's economy. In the production of wool, meat, dairy products, hides, &c., the health and well-being of the animals themselves are basic to the industrial production which stems from them.

The Division of Animal Health and Production is responsible within the framework of the Organization's programme of research for the animal industries, and undertakes investigations on animal health and reproduction, and animal husbandry.

The head-quarters of the Division is located in Melbourne, but its activities are spread throughout the Commonwealth. Reports on work in progress are presented in this Chapter and in Chapters VII. and VIII.

The work of the Division of Biochemistry and General Nutrition on nutritional problems is reported in Chapter VI. Section 12 of this Chapter deals with investigations of the Animal Genetics Section other than those on sheep and cattle which are included respectively in Chapter VII., Section 15, and Chapter VIII., Section 9.

Division of Animal Health and Production.—The decentralization of the administration of the Division, implemented with the establishment of the Committee of Management, continues to work well. This system is paving the way towards the formation of a number of principal units within the Division which are autonomous as regards administration but which are effectively linked at the research level.

The research programmes of the Division have continued on the broad lines of previous years, with work on diseases of cattle, contagious pleuropneumonia, infectious forms of infertility, cattle tick, and worm parasites being currently of greatest national importance.

Following the deliberations of the Cattle Tick Research Review Committee, work commenced on the protozoal blood parasites which cause " tick fever " in cattle; the loss of resistance to tick fever which may result from tick control measures is a serious hindrance to their wide and thorough application in northern Australia.

The major cattle production problems are: increasing by improved husbandry the turn-off of beef to southern Australia where European breeds find a suitable climatic environment, and selection of cattle which can thrive in our hot-arid and hot-humid northern environments. To do this, it is essential to understand the physiological characteristics which determine heat tolerance in cattle and then to select from them within the European breeds or to impart them by crossing with such breeds as the Zebu or Afrikander. This takes time, but good progress is being made.

Research on sheep diseases has currently been reduced since knowledge gained in recent years, and the advent of modern insecticides have diminished the significance of the sheep blowfly and other external parasites. Diseases receiving special attention are footrot and foot abscess, mycotic dermatitis, and worm parasites.

Sheep husbandry and wool production are two of the Division's major research undertakings. The objectives are: to understand the genetic basis of high wool production, so that the most desirable and highly productive animals can be selected, and their qualities transmitted to their progeny; to understand the nutritional and other physiological mechanisms which enable the inherited capacity for high wool production to be manifested; to reduce the heavy losses which result from poor fertility and neo-natal mortality in lambs; and to discover the best and most economic means of offsetting the effects of drought by appropriate maintenance rations and husbandry. Basic physiological research on sheep is required, ranging from the factors controlling food intake and utilization, to the development of wool follicles in the foetal lamb, and to the physiological and environmental factors which determine wool production after birth and in adult life.

At the instigation of the Division, and through the medium of the Animal Production Committee and its animal industry sub-committees, the present status of animal husbandry and production investigations by Commonwealth and State organizations is under review to reveal the nature of the major problems on which attention can most usefully be focused, so that resources can be integrated to best advantage.

2. ANIMAL HEALTH RESEARCH LABORATORY, MELBOURNE.

(Division of Animal Health and Production.)

In the investigation of some of the major diseases of live-stock in Australia special attention is being paid to contagious pleuropneumonia of cattle (see Chapter VIII., Section 2) and to the causes of infertility in cattle, particularly in dairy herds (see Chapter VIII., Section 2). In both of these fields of research, studies are based upon the use of cattle as experimental animals, and special facilities are required to keep these under conditions of quarantine. Although these investigations are limited by high costs and practical requirements, progress has been satisfactory. With pleuropneumonia, the Australian work has been in the forefront of world research. In addition to aiding the cattle industry in Australia by devising and supplying a vaccine which has kept the disease under control, supplies of materials for the Organization's serological diagnostic test have been sent to several afflicted countries overseas, and general advice has also been given. With sheep diseases, studies on chronic copper poisoning and heliotrope poisoning have been continued. These causes of death in sheep are generally associated with jaundice in the sick animal, and the chemical pathology of the diseases opens up a wide and important field of research both in sheep (see Chapter VII., Section 17) and in animals other than sheep (see Chapter V., Section 11).

Other items of research include studies associated with trace element diseases of livestock in Western Australia (see Chapter V., Section 11, Chapter VII., Section 17, and Chapter VIII., Section 2); plant poison studies (see Chapter V., Section 11); avian leucosis (see Chapter V., Section 11); toxicity of large rations of wheat (see Chapter VII., Section 12); infertility and physiology of reproduction in sheep (see Chapter VII., Section 13); brucellosis of sheep (see Chapter VII., Section 17); and clover oestrogen studies (see Chapter VII., Section 21).

3. McMaster Animal Health Laboratory, Sydney.

(Division of Animal Health and Production.)

The installation of a refrigerated laboratory in the basement of the Ian McMaster Wing makes a very valuable addition to the facilities.

Sustained dry weather over eastern Australia hampered the field work on such conditions as footrot and mycotic dermatitis of sheep and delayed the establishment of improved pastures at the Parasitology Block of the F. D. McMaster Field Station.

The major investigations undertaken at the laboratory are a study of heritability of fleece and mutton characteristics (see Chapter VII., Section 14); studies on external parasites of sheep (see Chapter VII., Section 19); studies on anthelmintics and the relationship between the sheep and its internal parasites (see Chapter VII., Section 18); drought feeding and the utilization of low-quality roughage (see Chapter VII., Section 11); pregnancy toxaemia, footrot, and mycotic dermatitis of sheep (see Chapter VII., Section 17); and fattening of beef cattle (see Chapter VIII., Section 7).

4. Veterinary Parasitology Laboratory, Yeerongpilly, Queensland.

(Division of Animal Health and Production.)

This Laboratory devotes the major part of its research programme to investigations on the internal parasites of cattle. Other problems of importance to the livestock industry are studied as staff and facilities permit.

Accommodation and facilities are provided for officers of the Division of Entomology who are engaged in field and laboratory research on the ecology and control of the cattle tick, *Boophilus microplus*.

Facilities for field work by both Divisions are available at Amberley Field Station, about 25 miles from the Laboratory.

Investigations in progress include studies on: parasitic gastro-enteritis of cattle (see Chapter VIII., Section 3); and ticks infesting cattle and cattle-tick fevers (see Chapter VIII., Section 4).

5. F. D. McMaster Field Station, Badgery's Creek, New South Wales.

(Division of Animal Health and Production.)

Seasonal conditions continued to be difficult, there being no run-off rains for the twenty-month period June, 1956-February, 1958.

Reserves of water for irrigation became exhausted in November, 1957, and irrigated pastures were abandoned. When drought breaking rains were received during February and March, stock water was also at a low ebb.

Following the rains, pasture regeneration was good and further areas of improved pasture were sown.

Improvements effected during the year comprised the sinking of two new stock water dams, the laying of irrigation mains at another dam, the erection of new bull yards, and the construction of a small temperature-control room capable of housing two cattle. Two large circular water troughs (500 and 1,000 gal. respectively) were built for use by the dairy cows. Further drains and concrete pads were laid around the cow shed and cow yards.

Major investigations on the Field Station are: studies on inbred flocks of Australian Merinos (see Chapter VII., Section 14); inheritance of component fleece characters (see Chapter VII., Section 14); biological studies of skin and wool growth (see Chapter VII., Section 16); development of the Zebu cross dairy herd (see Chapter VIII., Section 6); studies on hair growth of cattle (see Chapter VIII., Section 6); and studies on the sweating of cattle (see Chapter VIII., Section 6).

6. Sheep Biology Laboratory, Prospect, New South Wales.

(Division of Animal Health and Production.)

The research team for this Laboratory is gradually being built up, and new research projects are being developed, notably in the field of climate physiology (see Chapter VII., Section 22). Other investigations reported in Chapter VII. are: Section 10, the metabolism and nutrition of sheep; Section 13, physiology of reproduction; Section 16, biological studies on wool growth and the skin; and Chapter VIII., Section 7, skin and hair growth in cattle.

Most of the Laboratory's work is concerned, directly and indirectly, with wool growth, and requires large numbers of sheep, both in pens and in the field; the carrying capacity of the Prospect pastures has been enhanced by the construction of a " turkey-nest " dam which is filled from two small streams flowing through the property.

As in previous years the Fleece Analysis Laboratory provided a service for measurements on fleece and cattle hair samples for some of the research projects described in Chapter VII., Sections 14 and 16, and Chapter VIII., Section 7. Altogether 35,780 measurements of various kinds were made on wool samples, including the scouring and extraction of greasy wool samples, and physical measurements of staple and fibre properties. An additional 1,248 physical measurements were performed on cattle hair samples.

7. Regional Pastoral Laboratory, Armidale, New South Wales.

(Division of Animal Health and Production.)

The present research team consists of officers of the Divisions of Animal Health and Production, Plant Industry, and Mathematical Statistics. Accommodation is also provided for officers of the Wildlife Survey Section. Close liaison is maintained with the Faculty of Rural Science, University of New England, and several co-operative investigations have been commenced. Stock and facilities have been provided for field work for officers from the McMaster Animal Health Laboratory, the Sheep Biology Laboratory, the Wool Textile Research Laboratories, the Animal Breeding Section, and the Division of Plant Industry.

Investigations in progress by officers of the Division of Animal Health and Production include: effect of nutrition on reproduction in sheep (see Chapter VII., Section 13); thyroxine and wool growth under field conditions (see Chapter VII., Section 16); posthitis in wethers (see Chapter VII., Section 17); internal parasites (see Chapter VII., Section 18); drought feeding of cattle (see Chapter VIII., Section 7); and coat clipping studies in cattle (see Chapter VIII., Section 7).

The Division of Plant Industry programme includes: plant introduction, pasture ecology and autecology, plant nutrition, legume nodulation, pasture management, and utilization studies. Particular attention is being paid to the role of sulphur in plant nutrition.

At " Chiswick " an area of 1,305 acres has been cultivated and sown. In addition approximately 980 acres of native pasture have been surface seeded with grasses and clovers. Sheep shorn in 1957 were 6,559 for 241 bales of wool, an average of 9.8 lb. per head including crutchings.

8. National Field Station, " Gilruth Plains ", Cunnamulla, Queensland.

(Division of Animal Health and Production.)

During the calendar year 1957, only 7.76 inches of rain were recorded and for the twenty months to the end of March, 1958, the total rainfall was only 13.00 inches; the year therefore has been one of drought conditions. There has not been a good growth of summer-growing perennial grasses for two consecutive summers; a number of these plants have died, and, of those still living, much of the dried leaf and stem growth of previous wet years has been eaten or has disintegrated.

Lamb marking percentages and wool cuts have been low. Two-tooth medium Peppin ewes cut 8.8 lb. of greasy wool for twelve months' growth. As a drought mitigation measure, approximately 1,500 lambs were weaned prematurely and fed lucerne hay in yards for four months. This enabled the natural pastures to be used to better advantage for the ewes as, after weaning, they required only a maintenance level of feed intake.

Sheep breeding experiments AB1, AB4, and AB5 have been continued (see Chapter VII., Section 14), and work has commenced on the study of relative feed/wool conversion efficiencies of sheep under field conditions.

9. NATIONAL CATTLE BREEDING STATION, "BELMONT", ROCKHAMPTON, QUEENSLAND.

(Division of Animal Health and Production.)

"Belmont", situated on the Fitzroy River some 20 miles north of Rockhampton, was acquired by the Australian Meat Board and made available to the Organization for work on beef cattle production. The main programme of the station, which is 7,000 acres in area, and has a carrying capacity of 1,400 head, is directed towards studies in adaptation of British breeds and their crosses with exotic breeds to a tropical environment.

The winter and spring weather of 1957 was distinctly dry and cold, and some anxiety was felt for the breeding herd. However, following an early weaning, the pastures maintained these stock better than expected and they came to calving (October-November) in quite fair condition. During the first four months of 1958 some 15 inches of rain fell. This produced a heavy growth of pasture and two floods in the Fitzroy River in February and March. Fortunately flood damage to pasture was not severe, and following useful rains in May and June the property and stock entered the winter of 1958 in excellent order.

Developmental work was continued and a further 120 acres of softwood scrub land was cleared, burned, and sown down. Other improvement work included the clearing of 1 mile of dense scrub for the erection of the power line, the completion of a 300-ft. air strip, and the erection of two small buildings and a calf mothering yard.

The fifth series of experimental matings was successfully completed during the early months of 1958 (see Chapter VIII., Section 8).

10. POULTRY RESEARCH CENTRE, WERRIBEE, VICTORIA.

(Division of Animal Health and Production.)

Long-range studies on population genetics continue to form the main projects. They are supported by physiological and biochemical studies to investigate further the mechanism of heterosis (see Section 11 of this chapter).

For the 1957 breeding season a total of 1,102 dams were used and artificially inseminated with diluted semen of 120 sires. Husbandry techniques remained unchanged from those used in previous years. Birds on the property on 1st April, 1958, totalled 4,961 of which 4,129 were females of laying stage, including 2,186 White Leghorn, 615 Australorp, and 1,270 crossbreds of various types.

11. INVESTIGATIONS OTHER THAN WITH SHEEP AND CATTLE.

(Division of Animal Health and Production.)

(*a*) *Avian Leucoses.*—Experiments have continued at the Animal Health Laboratory, Melbourne, and the Poultry Research Centre, Werribee, to determine the effect, on the incidence of this disease in adult life, of isolation during the brooding period. The overall incidence during the current experiment may prove too low for reliable conclusions to be drawn.

(*b*) *Studies in Population Genetics.*—This work continued at the Poultry Research Centre. The following findings result from an analysis of egg production to 72 weeks of age of the 1956 hatched L-generation of pullets:

(i) The production-bred flock of White Leghorn, selected on an index combining individual and family performance, averaged 201.4 eggs on a hen-housed basis, 41 eggs more than the unselected control flock. Despite continuous breeding from pullets adult mortality was at the low level of 10.6 per cent.

(ii) The three inbred strains with an average coefficient of inbreeding above 70 per cent., which had been subjected to a limited amount of artificial selection, produced about the same number of eggs on a survivor basis as the unselected but non-inbred control flock, though two of the strains show much higher adult mortality.

(iii) The three-way incrosses produced by mating inbred sires of one strain to two-way incrossed dams showed disappointing results and remained below the level of the non-inbred flock described under (i). Considering the size of feasible breeding operations in Australia this method of producing "hybrid chickens" does not seem to be promising.

(iv) The ninth and final generation of the flock selected according to the Hagedoorn nucleus system of continuous half-sib matings confirmed the adverse conclusions previously reported, and produced only slightly above the unselected but non-inbred control flock.

(v) The single crosses between White Leghorn and Australorp from reciprocal recurrent selection were again superior in egg production on the survivors' basis to the best purebred production-bred flock, but lost most of this superiority on the hen-housed basis on account of nearly twice as high mortality. A special study of nine generations of single crossing confirmed previous preliminary reports of the high amount of heterosis shown by this cross for egg production of survivors, hatchability, and chick mortality, but could not confirm the widely held view that the LxA is superior to the AxL cross.

The tenth generation of criss-crosses established a new flock record at this Centre with 229.7 eggs on a hen-housed basis at 72 weeks of age.

The study of heritability of chick viability was completed and the following estimates obtained: 3.5 ± 1.5 per cent. for White Leghorn and 3.9 ± 2.3 per cent. for Australorps for the period 0-3 weeks, and 4.3 ± 1.6 per cent. and 3.0 ± 2.2 per cent. respectively for the first 6 weeks of life.

The following studies were continued to accumulate sufficient data for a final analysis:—

(i) The heritability of second-year egg production and its genetic correlation with first-year egg production;

(ii) the interaction between genotype and two different environments (cages and deep litter).

Studies were made on optimal flock structure of a poultry flock resulting in the construction of appropriate equations for the solving of this problem, and on genetic improvement as related to size of breeding operation. A refined method is also under investigation for measuring "pausing" which is a component character of egg production.

(*c*) *Avian Physiology and Nutrition.*—An experiment was completed at the Poultry Research Centre to show the effect of egg production of possible interactions between four breeds (White Leghorn, Australorp, and the two reciprocal crosses) with three levels of protein (15, 11, and 9 per cent.) in the ration. The results are still under statistical analysis but do not appear to indicate significant interactions. The decline in egg production at the lowest level of protein intake was comparable in each of the four breeds.

A series of experiments was commenced in which the amino acid requirements of these four breeds will be studied by feeding rations deficient in certain amino acids to growing chicks and observing growth rate and mortality up to three weeks of age.

(*d*) *Comparative Biochemistry of Copper*.—Investigation has continued at the Department of Agriculture, Perth, of the copper metabolism of fowls and ducks. In the cockerel, evidence has been obtained that copper may be excreted from the body mainly with the bile and partly through the caecum; evidence of biliary excretion was also found in drakes but data from the analysis of caecal contents was difficult to interpret. Some preliminary experiments with mice showed that, like most animals other than ruminants, they are able to restrict liver storage of copper when it is fed in excess of usual amounts.

(*e*) *Plant Poison Studies*.—This work has continued at the Animal Health Laboratory, Melbourne.

(i) *Plants Containing Pyrrolizidine Alkaloids*.—Investigation has continued of the pathology of acute and chronic poisoning in rats by the pyrrolizidine group of alkaloids, principally those from the plant *Heliotropium europaeum* which causes losses among sheep. The disease process set up in the liver by a single sublethal dose of these alkaloids is a progressive one and, given sufficient time, it will cause liver changes similar in nature and degree to those produced by repeated doses. Other alkaloids of the group, with only a minor difference in ring structure of the molecule, have produced no liver damage even when given in repeated doses over long periods.

(ii) *Other Plants*.—Toxic extracts of *Atalaya hemiglauca* have been further purified, with the aid of toxicity tests in small animals, but the toxic principle has not yet been finally isolated. Further long-range experiments with the pure alkaloids of *Lupinus varius* L. have yielded no evidence that they are capable of causing liver damage.

(*f*) *Trace Element Studies in Western Australia*.—The results of surveys made in co-operation with the Western Australian Department of Agriculture over a period of more than 10 years and covering an area in the extreme south-west of the State have been prepared for publication.

(*g*) *Growth of the Marsupial* Trichosurus vulpecula (Sheep Biology Laboratory).—Observations on the growth of the brush-tailed possum (*T. vulpecula*) and a comparison with man, cow, sheep, and mouse have been completed at the Sheep Biology Laboratory.

(*h*) *Physiology of Reproduction*.—To provide a sound basis for studies on the fertility of domestic animals, especially sheep and cattle, physiological work has been undertaken on reproduction in rats and mice. Special attention has been given to the phenomena of ovulation, sperm transport and facilitation in the female genital tract, the processes of fertilization, and factors influencing early pre-natal mortality.

12. ANIMAL GENETICS.

(Animal Genetics Section.)

The Animal Genetics Section aims to investigate the possibility of applying genetics to animal breeding and allied fields and to train students interested in this subject.

Two M.Sc. students and one Ph.D. student have completed their training and one honours student has begun this year. A post-graduate student from America has been accepted. Four students are studying for the Ph.D. degree. The course of 10 lectures on animal breeding given to veterinary students has been taken over by a former student of the Section now lecturing in the University.

(*a*) *Genes and Chromosomes and other Granules*.—Mutation rate in *D. melanogaster* has been shown to decrease with rise in temperature when the effects of age of male and time of storage of sperm are removed. The relationship holds for temperatures between 15 and 30° C. The suggestion that a longer developmental time increases mutation rate appears to be untrue. The negative association of mutation rate and temperature is contrary to most assumptions and to the idea that mutation rate is proportional to thermal activity.

Selection for a reduction in the number of abdominal chaetae in *D. melanogaster* has resulted in the fixation of a gene in at least two lines which removes the abdominal bristles almost completely. The way in which the gene made its appearance shows that it was present in the original stocks from which the selection lines were started. The shift in genotype due to selection appears to have made a background against which a previously harmless gene has become highly effective. In addition to its effect on bristles the gene causes sterility.

Interaction of genes affecting bristles has been shown for the scute gene in *D. melanogaster* which removes some bristles and for the hairy wing gene which adds extra ones. The genes are very closely linked, and crossing over is unrecorded; however, a supposed crossover was isolated. It was HwSc, and when selected for expression responded by producing a high proportion of HwSc phenotypes. As no crossovers separating the two genes have occurred on outcrossing the interpretation is still in doubt. The original flies may not have been genetically HwSc.

The double embedding method of preparing sections for electron microscopic study has been used to treat sections after examination with ribonuclease and desoxyribonuclease and proteases. This has enabled iron to be established as a nucleic acid stain and phosphotungstic acid as a protein stain. The nucleus is filled with filaments composed of a desoxyribonucleic acid core and a protein sheath. The protein sheath strips off when antibody or virus is being formed. When antibody is being formed the nucleus loses its uniform appearance, and aggregates of dense material accumulate at the periphery. The membrane of the endoplasmic reticulum in the cytoplasm becomes dilated with secretion which is expelled, possibly through pores in the cell membrane, with which the membranes of the reticulum are continuous. The denuded nuclear filaments appear to elaborate ribonucleoprotein granules which pass out of the nucleus and become arranged along the membranes of the endoplasmic reticulum.

Cells infected with and synthesizing influenza virus undergo similar changes. Dense clumps rich in ribonucleic acid (RNA) which are a tangle of filaments pass into the cytoplasm moving towards the cell membrane, where they protrude into membraneous evaginations which constrict off liberating virus particles into the intercellular spaces. The particles have an RNA protein core which is made of a tangled filament of about 50 Å in thickness. The length can be calculated as approximately 1.5μ.

(*b*) *Myxomatosis*.—The size of the population of rabbits being selected for resistance to myxomatosis has increased rapidly. The use of Uriara virus as a challenge has made selection for resistance much easier. The most forward generations now have a recovery rate of 20 per cent. when challenged with KM_{13}, and 67 per cent. when challenged with Uriara. This results from the equivalent of two to two and a half generations of selection on both sides of the pedigree. There is a marked seasonal variation. Despite heating in the rabbit house, survival drops to 6 and 25 per cent. respectively in the winter. A small colony of wild rabbits, offspring of known survivors in the field, has been started.

(*c*) *Serology*.—Correlation of response by rabbits to antigens of different kinds shows that the degree to which a rabbit responds to one antigen is, in general, not a good guide to the way in which it will respond to others. There is some general correlation which suggests that some rabbits are overall better at antibody production than others. The closest correlations found were between responses to influenza virus mel and lee antigens. This correlation was more than 0.90. There was a high (0.50–0.60) correlation between response to tobacco mosaic virus and mel or lee. It follows that in the absence of further evidence there is no certainty that a new virus, effective on rabbits never exposed to myxomatosis, would be able to cope with a population selected to live with myxomatosis. Attempts at selection of new viruses for field use will be approached with this in mind.

Anaphylaxis.—The heritability of anaphylactic sensitivity to bovine plasma albumin is high (0.92).

(*d*) *Mice*.—The work on the induction of phenocopies by X-radiation has reached the conclusion of the initial phase, and shows that the determination of simple developmental structures such as the facial vibrissae does not differ in the time range of its sensitivity to radiation from that of more complex structures. Further work is being commenced to examine the relationship of sensitivity to the detailed sequence of initiation of vibrissae, and is aimed at determining whether phenocopies are the result of death at critical cells, or of transformations of developmental potential.

Work on selection for an invariant character has been continued and extended, and demonstrates that the invariance can be destroyed by selection in the presence of mutant genes. Various experiments are determining the genetic variability of individual whiskers.

A survey has been completed of the incompatibilities to skin grafts between sib lines of inbred strains. Two sib lines have been found to show such incompatibility, which indicates that the number of genes controlling skin graft incompatibility, although large, is only a fraction of the total genotype. This survey is being repeated and the two incompatible sib lines are being investigated in more detail.

(*e*) *SILLIAC*.—The SILLIAC, an automatic electronic digital computer, has been used in the simulation of genetic systems. The first analyses set the machine to simulate the processes of segregation, recombination, reproduction, and selection in populations mating at random within the selected parents. The genetic system was of six loci. It was shown that in such a system, recombination had no qualitatively detectable effects at values greater than 0.05, but that qualitative breaks in the rate of advance under selection occur where recombination is of the order of 0.025–0.005. Such breaks occur only in small populations.

The second analyses in progress have as their basis a more complex genetic system in which the basic genetic system of five loci is the focus of the effects of a dominance genotype of five loci, and of two other interaction genotypes, each of five loci. The result is a model approximating to the complexity of actual genetic systems. Runs with this model have shown that selection against extremes results in a decrease of any dominance, and an increase of interaction, i.e. the deviations due to dominance decrease, while those due to interaction increase. The information which can be extracted by this method will be considerably extended by the addition of a magnetic backing store to the SILLIAC. There will then be no theoretical limits to the size of the population that can be simulated, or the size of the genetic system.

(*f*) *Sweat Glands in Cattle*.—The work of the Animal Genetics Section on the adaptation of cattle to hot climates is reported in Chapter VIII., Section 9.

(*g*) *Genetics of Sheep*.—The work of the Animal Genetics Section on the genetics of sheep is reported in Chapter VII., Section 15.

VI. NUTRITION.

1. GENERAL.

The Organization, early in its development, realized that nutritional deficiencies impair very seriously the efficiency of the Australian grazing industry, and so founded the Division of Animal Nutrition (now the Division of Biochemistry and General Nutrition) to study the nutrition of ruminant animals and to determine and correct the limitations imposed on the nutrition of grazing flocks and herds by climate and terrain. The Division has developed into an institute for the study of the nutrition of the wool sheep, but many of the results of its studies are similarly applicable to the meat-producing industry.

Many applications arising from these studies have already found their way into practice to increase materially the overall efficiency of sheep husbandry. Some of these discoveries, for example, those which led to a realization of the nutritional importance to plant or animal of traces of heavy metals, cobalt, copper, zinc, &c., have been responsible for revolutionary changes in Australian agricultural practices.

The current investigations of the Division are described in this Chapter, in Chapter III., Section 8, and in Chapter VII., Sections 2-9.

The Organization's other investigations bearing on sheep nutrition are reported on in Chapters III., V., and VII.

Division of Biochemistry and General Nutrition.—The research programme of the Division has continued in the pattern established in previous years.

Work has continued at the Division's field stations. At Glenthorne experiments are being conducted on salt tolerance and supplementary feeding; at Robe cobalt and copper deficiencies are being investigated; and at Brecon and several other locations in South Australia, trials are being made on the cobalt pellets developed to protect sheep from cobalt deficiency and phalaris staggers.

2. NUTRITION AND WOOL PRODUCTION.

(Division of Biochemistry and General Nutrition.)

A series of experiments has been begun to provide information on the efficiency of utilization of fodder protein by high producing Merino sheep. These aim to explain the supplementary relationship between the fodder proteins derived from the higher plants and the proteins derived from microorganisms within the paunch.

3. METABOLIC PROCESSES OF SHEEP.

(Division of Biochemistry and General Nutrition.)

Investigations are continuing to extend knowledge of the way in which matter and energy are dealt with in the metabolic processes of ruminants. These studies are important to the understanding of the nutrition of sheep and cattle because little is known of the channels through which these animals metabolize the simple fatty acids. These acids—which arise from the fermentation of carbohydrates in the rumen—are of primary importance to ruminants in providing the greater proportion of the fuel from which the animals derive the energy necessary to sustain their physiological processes.

Special studies are being made of those channels of intermediary metabolism in which the cobalt-containing accessory food factor, vitamin B_{12}, plays an essential role. A soundly based understanding of these processes is essential for the recognition and correction of metabolic disorders. Individual researches that concern these problems are referred to in more detail in Chapter VII.

4. ENERGY METABOLISM OF THE SHEEP.

(Division of Biochemistry and General Nutrition.)

Studies have continued to provide further knowledge of the thermodynamics of the living processes of the sheep. The mass spectrograph procured for the determination of $^{14}N/^{15}N$ ratios necessary for an understanding of certain aspects of protein metabolism was rebuilt and now is capable of the sensitivity and reliability required for these studies. Attention is being given to the calorimeters and their subsidiary instruments to determine whether a gas-density balance or a thermistor device can be used for estimation of the amount of oxygen consumption, in place of the present tedious and exacting direct gas analysis.

The application of the findings of current experiments on energy metabolism to problems of sheep nutrition are referred to in Chapter VII.

5. MICROBIOLOGICAL PROCESSES OF RUMINANTS.

(Division of Biochemistry and General Nutrition.)

Ruminants depend primarily upon the complex population of micro-organisms in the rumen contents. These organisms ferment the complex carbohydrates in the fodder to the simple fatty acids utilized by the animal to fulfil its energy requirements. They also synthesize, from simpler substances, accessory food factors essential for the animal's well-being. Under certain circumstances, they produce important amounts of protein.

The Division's researches on the rumen microflora are referred to in Chapter VII.

6. SALT TOLERANCE OF SHEEP AND POTABILITY OF STOCK WATERS.

(Division of Biochemistry and General Nutrition.)

The first series of experiments to provide basic knowledge of the tolerance of sheep to bore-waters of various degrees of salinity has been completed. A combined account of the findings from the second series is given briefly in Chapter VII.

7. CARBOHYDRATES AND STEREOCHEMISTRY.

(Division of Biochemistry and General Nutrition.)

The studies have continued of the stereochemistry of carbohydrates to illuminate certain functional aspects of carbohydrates in living processes.

As the result of the programmes of studies of the ionophoretic behaviour of carbohydrates and related compounds, data are now available for 96 compounds in four electrolytes. All classes of carbohydrates and glycols likely to be encountered in practice are represented in this series, and this work defines the practical utility and limitations of the method. By choosing the appropriate electrolyte it should now be possible to separate the components of any mixture of common carbohydrates likely to be encountered, without recourse to paper chromatography. The time required for separations is less and the likelihood of positive identification of the components is greatly increased. Methods for locating the carbohydrates after separation on the paper are now available, and some of the reagents developed are specific for certain classes of carbohydrates. The investigation is the first detailed study of the detection of carbohydrates in the presence of inorganic electrolytes.

Some correlations between structure and mobility are possible which should permit deductions to be made about the structure of an unknown carbohydrate from its mobility in paper ionophoresis. Attention is now being concentrated on this aspect of the problem.

An ancillary study of paper chromatography has yielded further data which indicated that R_F values of reducing sugars and inositals may be correlated with configuration if conformational factors are taken into account. The influence of the size and magnitude of molecular rotation on configuration are also being studied, and also the ionophoretic behaviour of phenols and hydroxy acids.

8. MINOR ELEMENT DEFICIENCIES IN ANIMALS.

(Division of Biochemistry and General Nutrition.)

Researches have continued on the nutritional significance of minute traces of heavy metals. Studies of problems associated with deficiencies of these elements concern specifically the welfare of grazing animals, and are reported elsewhere in this review (see Chapter VII.). Those which concern pasture development are mentioned in Chapter III., Section 8.

Besides these applied studies aimed directly at solving problems of the pastoral industry, attention is being given to physiological and biochemical studies of a more fundamental nature.

Nutritional investigations into the functions of copper in metabolism have been completed. In some of these studies rats have been employed as experimental animals. The findings have extended knowledge of the influence that various ions—molybdate, sulphate, &c.—exert on the absorption, retention, and utilization of copper. This work adds considerably to the understanding of the mechanisms that underlie the condition of imposed copper deficiency of flocks and herds grazing on fodder containing enough copper, normally, to meet the animals' requirements.

A study of the influence of copper on the physiological process of keratinization undertaken to provide knowledge fundamental to the understanding of the physiological processes of wool production is nearing completion.

Experimental studies are being undertaken of the influence of vitamin B_{12} deficiency on the intermediary metabolism of acetic and propionic acids in search of the metabolic lesion imposed in ruminants by cobalt deficiency.

The influence of zinc deficiency on the rate of protein turnover in the rat is being investigated in the course of studies of the metabolic effects which supervene on zinc deficiency in animals.

9. VITAMIN B_{12} AND COBALT METABOLISM.

(Division of Biochemistry and General Nutrition.)

Research has continued to provide knowledge necessary for the detection and correction of cobalt deficiency in grazing ruminants.

Detailed investigations are in progress of the nature of the metabolic lesions induced by cobalt deficiency, which, in turn, involve study of the physiological processes supported by vitamin B_{12} and by folic acid.

Current experiments have taken two main courses, viz., physiological studies in which intact animals (sheep mostly) are employed, and biochemical studies in which tissue preparations are studied *in vitro*. Both approaches have yielded important information. The former has proved that the cobalt deficient animal loses its ability to utilize fatty acids at a normal rate, and the latter has indicated that homogenates prepared from the livers of deficient sheep are unable to metabolize propionic acid. These studies have indicated the link in the chain of metabolic processes that fails in vitamin B_{12} deficiency and the association of this link with the function of folic acid.

Applications to several problems of cobalt deficiency in grazing ruminants are referred to in Chapter VII.

10. PLANT NUTRITION.

(Division of Biochemistry and General Nutrition.)

The physiological study of the function of zinc in plants and of the anatomical lesions that supervene when pasture species become zinc deficient has been continued. A brief précis of the findings is reported in Chapter III., Section 8.

11. PROVISION OF COBALT TO RUMINANTS BY HEAVY PELLETS.

(Division of Biochemistry and General Nutrition.)

This work is described in Chapter VII., Section 7.

12. NITROGEN SUPPLEMENTS FOR SHEEP.

(Division of Biochemistry and General Nutrition.)

This work is described in Chapter VII., Section 8.

VII. SHEEP.

1. GENERAL.

Australia produces one-quarter of the world production of wool of all types, and more than half the world production of fine wool. The sheep population of Australia is approximately 150 million. The sheep therefore holds a unique position in the Australian economy. Wool is our major export, and primary products from the sheep industry such as wool, lamb, mutton, and hides comprise up to 45 per cent. of all Australian rural production. The sheep, too, allows of the use of vast areas of marginal land which it has not so far been practicable to use for other purposes.

Thus Australia has a vital interest in ensuring that wool can withstand competition from artificial fibres. The remarkable success of the latter has been due to the clear understanding, arising from research, of the physical and chemical properties of the new fibres. Moreover, the chemical industry established to produce them is planned as a co-ordinated and organized unit, which ensures maximum efficiency and minimum wastage at all stages.

It is a major aim of the Organization's integrated programme of research in aid of the wool industry to investigate every phase of sheep and wool production; soil, pastures and nutrition, genetics, animal husbandry, wool processing, textile manufacture, and the exploitation of by-products. The Organization has been given responsibility by the Commonwealth Government for carrying out this extensive programme, and special funds have been set aside for this purpose.

Soil fertility is obviously of prime importance, and outstanding results have been achieved in improving soil infertility arising from minor element deficiencies. On the plant side, too, special emphasis has been placed on pasture improvement and weed control. The work of the Organization on soils, pastures, and related matters affecting the pastoral industry is carried out by the Division of Soils, the Division of Plant Industry, and the Division of Entomology (see Chapters II., III., and IX.).

Work on the sheep itself has been undertaken within the Division of Animal Health and Production (see Sections 10-19 and 21-22 of this Chapter) and the Division of Biochemistry and General Nutrition (see Sections 2-9 of this Chapter). The Division of Mathematical Statistics is closely associated with the breeding investigations. The Animal Genetics Section's work on sheep breeding is described in Section 15 of this Chapter, and that of the Division of Entomology on the sheep blowfly in Section 20 of this Chapter.

The Organization's work in the investigation of wool processing and wool textile problems is undertaken at the Wool Textile Research Laboratories and the Division of Industrial Chemistry (see Chapter XVI.).

2. NUTRITION AND WOOL PRODUCTION.

(Division of Biochemistry and General Nutrition.)

The study of keratinization initiated by the discovery of the important role played by copper in wool production has been continued. Various degrees of copper deficiency, absolute and imposed, have been produced in a series of Merino sheep; a series of histological and histochemical studies have been made on their wool follicles, and now a comprehensive chemical study is being made on the wool grown at various stages of deficiency.

Study has been made of processes of pigmentation, and of the effects of copper shortage on them, to gain knowledge of the chemical reactions that occur during the production of wool within the follicles.

Studies of the interrelationships between energy metabolism and protein turnover, delayed by faults in the mass spectograph, are again proceeding.

The aim of the work is to discover the nutritional and physiological factors responsible for the relatively low efficiency of the conversion of fodder protein to wool fleece, and to improve this efficiency. These experiments are closely associated with studies of the energy metabolism (see Section 4 of this Chapter).

3. MICROBIOLOGICAL PROCESSES OF RUMINATION AND FUNCTIONS OF FORESTOMACHS.

(Division of Biochemistry and General Nutrition.)

(*a*) *Passage of Digesta through the Sheep's Forestomachs.*—By application of the lignin-ratio technique, the extent of digestion of cellulose, pentosans, and total solids in the rumen, omasum, and abomasum was determined in sheep fed on several well-defined diets. Only well-digested material was found to reach the omasum and abomasum, even during the period immediately following the ingestion of fresh fodder. This selective conveyance of substances from the rumen made it clear that digestion of nutrients may be measured only in material which has actually left the rumen. The data showed that the extent of digestion of cellulose in the rumen varied from about 30 per cent. in one diet comprised mostly of highly lignified material, to more than 50 per cent. for lucerne hay. Digestion of the pentosans and of the total solids in both diets ran a closely parallel course.

Work has continued on the passage of nitrogenous compounds through the forestomachs. The proportion of the ingested nitrogen that reached the abomasum and duodenum was nearly 100 per cent. when the sheep was fed on wheaten hay (nitrogen, 1.1 per cent.) but only 48 per cent. when the sheep was fed on lucerne hay (nitrogen, 2.9 per cent.). Study of the nitrogen/lignin ratios in the compartments of the forestomachs throughout the day suggested that the balance was absorbed from the rumen.

(*b*) *Distribution of Nitrogen in the Rumen Contents.*—The fact that diaminopimelic acid is present in the rumen flora and is absent from the higher plants and from the rumen fauna was used as a basis for assessing the amounts of bacterial nitrogen present in mixtures of plant and microbial nitrogen in the rumen contents.

Estimates of the proportion of bacterial nitrogen in the total nitrogen indicated that, throughout the day, the proportions varied between 63 and 82 per cent. bacterial nitrogen, 11-27 per cent. plant nitrogen, and 5-10 per cent. soluble nitrogen. The extent of conversion of plant nitrogen in the fodder to microbial nitrogen is not necessarily indicated in these distribution patterns, since the material leaving the rumen differs in composition from that remaining. The figures for conversion to bacterial nitrogen indicated above appear to be minimal. Experimental determinations of similar distributions of the nitrogen in the contents of the omasum that are now being carried out should allow this important estimate to be made, together with a reasonable estimate of protein quality for ruminants.

4. ENERGY METABOLISM OF SHEEP.

(Division of Biochemistry and General Nutrition.)

Determinations were made of the heat production and overall energy metabolism of vitamin B_{12}-deficient animals to study the nature of the metabolic breakdown that occurs in cobalt deficiency.

Microcalorimeters have been constructed and investigations have commenced of the energetics of fermentation of cellulose, &c., by rumen organisms.

Instruments are being designed which may simplify the estimations of the oxygen consumed by the sheep, and the possibility is being examined of employing a gas density balance and subsidiary gear for metering the gas deficit.

The remodelled calorimeters will be employed for a comprehensive study of nutrition and wool production (see Section 2 of this Chapter).

5. CARBOHYDRATE METABOLISM OF THE SHEEP.

(Division of Biochemistry and General Nutrition.)

Studies have continued of the utilization of carbohydrates and of the volatile fatty acids by adult sheep and by young lambs, to investigate the metabolic differences between mature and young ruminants.

Very young lambs deal with acetic acid with extraordinary ease. After injection, acetate is disposed of by the young lamb at least twice as fast as by the adult sheep. This phenomenon is being studied further as it appears of basic importance to the understanding of the subsidiary paths of metabolism developed by adult ruminants.

In investigations into the utilization of carbohydrate, histological examinations are being made of the pancreas of young lambs and adult sheep. The insulin-producing cells of the islet tissue can be clearly demonstrated by methods employed for examination of the pancreatic tissues of non-ruminant animals. As the animals mature the β cells can be stained only with difficulty—modification of fixation and staining techniques is necessary.

The production of haemoglobinuria by certain proprietary preparations of phenobarbital utilized as an anaesthetic was observed and the reason traced to the effect of propylene glycol incorporated in the anaesthetic solution.

6. MINOR ELEMENTS IN THE NUTRITION OF SHEEP.

(Division of Biochemistry and General Nutrition.)

With the growth of knowledge of the maladies that supervene on shortages of minor elements it has become clear that the extent of areas that are affected in this way is very much greater than was considered probable when, in the earlier stages of the investigations, the studies were confined to terrain known to be seriously deficient. Disabilities imposed by deficiency of cobalt extend from the fatal, easily recognizable wasting malady suffered by ruminants confined to particularly affected areas, to milder deficiency stages, in which the condition is one of poor health rather than of outright disease. Seasonal disabilities imposed on grazing flocks and herds by these latter conditions which occur over very wide areas and seriously limit production take a greater toll from the grazing industry than resulted from the clearly deficient states before these were recognized and corrected. Easy and precise means of recognition of these incipient deficiency states are thus of more than theoretical interest.

Studies of the requirements and storage of vitamin B_{12} by Merino sheep have indicated that the extent of storage within the liver may be taken as a reliable criterion of the overall vitamin B_{12} status of grazing ruminants, and that the amount of the vitamin circulating in the blood stream probably reflects the cobalt status of the pastures at the time when the sample is taken. Thus a means is now available of assessing by surveys the seasonal disabilities imposed by shortages of cobalt in the fodder available from various types of grazing lands in Australia.

Preparations are being made for a comprehensive survey of this nature, to assess seasonal variations of the cobalt and copper status of flocks grazed under a wide variety of conditions throughout two or possibly three years. Very large numbers of microbiological assays will be involved. The equipment necessary to handle up to 1,000 vitamin B_{12} assays each week, utilizing the "Z" strain of *Euglena gracilis*, has been assembled and the details of the methods are being worked out. An officer will be sent abroad to acquire knowledge of manipulations employed to ensure reliable results when large numbers of microbiological assays are carried out as a routine.

The proposed surveys which will show unequivocally whether supplementary supplies of minor elements are needed will be awaited with interest now that simple and direct means are becoming available to deal with these deficiencies.

(*a*) *Cobalt Deficiency in Ruminants.*—Investigation of the metabolic disturbances that supervene when ruminants suffer a shortage of cobalt has been intensified. Cobalt deficiency influences primarily the composition of the mixed population of symbiotic micro-organisms which inhabit the paunch by limiting the development of those which produce vitamin B_{12}. Associated with the vitamin B_{12} deficiency which ensues is a shortage of folic acid, which becomes especially apparent in long-standing cases of cobalt deficiency. This secondary deficiency that appears when the sheep's fodder is seriously short of cobalt has been rendered apparent by the study of the folic acid concentration in the liver. When the concentration of vitamin B_{12} in the liver becomes reduced to relatively low levels (*c.* 0.2μg./g.) there is an associated sharp fall in the concentration of folic acid (and of the associated form, folinic acid).

A study of the capacity of the cobalt deficient sheep to deal with the simple volatile fatty acids, which comprise its main source of fuel, has revealed two types of metabolic disturbances, one in which the rates at which proprionate, acetate, and glucose are metabolized are all markedly depressed, and one in which only the rate of metabolism of propionate is retarded. The former condition reverts to the latter after parenteral injection of generous amounts of folic acid.

Experiments *in vitro* with homogenates prepared from the livers of normal and of deficient sheep have confirmed the inability of the vitamin B_{12}-deficient tissues to metabolize propionic acid and have indicated the point at which the metabolic breakdown occurs.

Further studies of the nature of the volatile and non-volatile acids that accumulate in the blood steam of cobalt-deficient animals have been made and have pointed the way to the metabolic lesion that supervenes on the deficiency. Appropriate techniques involving gas-liquid partition chromatography and partition chromatography on silica columns have been developed, and current microchemical means of estimating β-hydroxybutyric acid have been investigated and improved to render them suitable for the requirements of these investigations.

(*b*) *Copper Deficiency in Ruminants.*—Knowledge of the factors that influence the utilization of copper by grazing ruminants indicates that a deficiency state within the tissues can result from either a shortage of copper *per se* available in the fodder, or from complications in the absorption and utilization of copper brought about by excess of certain other elements present in the fodder which otherwise contains sufficient copper to meet the animal's requirements—hence the terms "absolute" and "induced" deficiencies.

One of the factors of prime importance to the absorption of copper by ruminants is the amount of sulphate in their fodder—for in the strongly reducing conditions within the rumen sulphate is converted to hydrogen sulphide which reacts with ionized copper to form the very refractory copper sulphide which is neither decomposed, nor absorbed at lower levels of the intestinal tract.

Complication of copper metabolism within the tissues of ruminants (sheep) and of omnivorous animals (rats) by other ions—molybdate, &c.—has been the subject of further studies which have indicated the physiological mechanisms that become impaired.

Studies of the effects that a deficiency of copper imposes on wool production are reported in Chapter VI., Section 2.

7. PROVISION OF COBALT TO RUMINANTS BY HEAVY PELLETS.

(Division of Biochemistry and General Nutrition.)

Research has continued with heavy objects, contrived to stay within the forestomachs and provide the modicum of cobalt necessary to ensure that all the microflora's requirements for this element are met.

Two factors are of the prime importance if the pellets are to stay in the reticulum and the rumen, viz. the density of the pellet and to a lesser extent its size. Steel pellets (sp.gr. 7.7) have not been lost by regurgitation under any of the conditions studied, whereas a very considerable proportion of pellets of sp.gr. 2.7 and 3.5 have been rejected under identical grazing conditions. Pellets of sp.gr. 4.0 are lost in some circumstances, but to a much smaller extent than those that are less dense.

The deposition of a concretionary layer of calcium phosphate on the pellets is a factor which is particularly troublesome under certain conditions—especially so when pellets are adminstered to young lambs that are still suckling. In these latter circumstances deposits may begin within a week or so after the pellets have been administered.

The effective life of the pellets produced commercially by slight modifications of the specifications laid down by this laboratory is seriously limited in certain circumstances by these deposits, which, incidentally, tend similarly to be laid down on pellets of entirely different composition. Besides this, certain pellets, particularly those to which alkaline silicates have been added during manufacture and which have been baked at high temperatures, tend to cease to give up cobalt after remaining for a period in the rumen. Direct observations of experimental sheep on cobalt deficient terrain have shown that the capacity of such pellets to provide the necessary amounts of cobalt to prevent vitamin B_{12} deficiency ceases after about a year, and that some pellets no longer protect sheep against phalaris staggers after a period of 12-15 months.

The underlying reasons for these complications are being investigated, and it is already clear that now that they are better understood these properties which mitigate the effectiveness of the pellets may be overcome.

Smooth heavy objects that lodge in the rumen and reticulum are well tolerated, and it is reasonable to believe that it will be possible to contrive heavy objects which will remain in the forestomachs and provide the requirements of the rumen microflora throughout the natural life of the animal. As the influence of variables met with under field conditions takes time to assess, it may be a year or so before the ideal pellet is produced.

8. NITROGENOUS SUPPLEMENTS FOR SHEEP.

(Division of Biochemistry and General Nutrition.)

Experiments to determine whether the useful protein of silage might be increased economically by adding urea or other simple sources of nitrogen during the ensiling process have now been concluded.

About 75 per cent. of the urea is hydrolysed to ammonia and only a very small proportion converted to protein.

Feeding tests indicated that no difference in the food value resulted from urea treatment of the silage, the criterion being body weight and wool production of matched groups of sheep that were confined to the respective silages for a period of 6 weeks. Another group, which received the control silage plus the protein equivalent of the nitrogen added originally as urea, produced 30 per cent. more wool. Thus no advantage is likely to be gained by adding urea during the ensiling process.

9. SALT TOLERANCE AND POTABILITY OF STOCK WATERS.

(Division of Biochemistry and General Nutrition.)

Sodium chloride in the drinking water for stock has been partially replaced by sodium sulphate. No untoward effects have been observed in many of the experimental sheep whose sole source of drinking water for the past year has contained 0.1-0.5 per cent. sodium sulphate imposed upon 0.9-1.2 per cent. sodium chloride.

The indications are that sheep may be confined to waters containing up to 0.9 per cent. sodium chloride plus 0.5 per cent. sodium sulphate without harmful effects, even when on dry feed.

10. METABOLISM AND NUTRITION OF SHEEP.

(Division of Animal Health and Production.)

(*a*) *Pregnancy Toxaemia Investigations* (Sheep Biology Laboratory).—Further evidence has been obtained on the critical role of the adrenal cortex in pregnancy toxaemia; the presence of elevated plasma hydrocortisone levels in affected ewes has been confirmed; observed metabolic abnormalities are completely consistent with the hypothesis that severe adrenal hyperactivity in hypoglycaemic, undernourished ewes precipitates the clinical syndrome.

In the light of recent work, the hypothesis that sudden, complete fasting is alone sufficient to induce the disease has been abandoned. The probable role of environmental (e.g. climatic) stresses has been insufficiently appreciated; undernourishment in ewes in late pregnancy is much more common than generally realized; such undernourishment predisposes the ewe to pregnancy toxaemia, which is actually precipitated by an environmental stress; preliminary experiments in climate-controlled rooms have shown that adrenal hyperactivity in response to the climatic stresses of wet, cold, windy conditions is vastly greater than that which occurs in response to the hypoglycaemia of complete fasting. Undernutrition may precede environment stress or may occur as a result of it (i.e. simultaneously).

The conditions under which glycerol is therapeutically effective are now well-defined; it is effective only when given in early pregnancy toxaemia induced in previously well-nourished ewes; it is completely ineffective in ewes severely undernourished for some time before the onset of the clinical syndrome.

The effect of climatic stress of pregnant ewes is being studied under controlled, laboratory conditions, together with the effect of undernutrition on the metabolism of hydrocortisone, and of the metabolic effectiveness of adrenal-depressant drugs.

(*b*) *Digestion in the Rumen.*—Work has been started on several aspects of digestion in the rumen. The use of " rumen markers " to measure the rate of flow of liquids and particles through the rumen has been examined; good results have been obtained with polyethylene glycol (originally described in Sweden) and with radioactive barium sulphate containing either ^{35}S or ^{140}Ba; radioactive chromium (^{51}Cr) as the complex with ethylenediaminete acid is being tested. An artificial rumen is being constructed to facilitate studies under controlled conditions *in vitro*; the rumen microorganisms will be maintained in a flowing system with continuous dialysis and samples will be automatically withdrawn for analysis. The nutrition of rumen microorganisms, and the rate of passage of ingesta along the digestive tracts are being studied. The growth rate (and hence, protein synthesis) of organisms in the rumen is especially important; an attempt is being made to measure this synthesis by exploiting the incorporation of radioactive sulphur (^{35}S) in microbial proteins during growth.

(*c*) *Nitrogen Metabolism in the Sheep's Rumen.*—Experiments have been initiated to investigate the rumen nitrogen metabolism in the special cases of sheep maintained on low nitrogen intakes or receiving grain supplements as in drought rations. Previous work has shown the importance in the rumen of ammonia nitrogen derived from fodder proteins, non-protein supplements, or salivary urea. Conclusive evidence has now been obtained that urea diffuses freely into the rumen from the blood stream and thereby contributes ammonia nitrogen after microbial hydrolysis; the magnitude of this diffusion is being measured. Simultaneous studies on ammonia absorption, rate of flow of rumen ingesta, and rate of fermentation of cereal meals will provide information to aid the formulation of diets in supplementary and drought feeding.

(*d*) *Protein Metabolism in Sheep.*—The synthesis of microbial proteins in the rumen tends to obscure the nutritional requirements of the host ruminant for amino acids. Experiments utilizing radioactive carbon as (1-^{14}C) acetate injected intravenously, indicate that the sheep needs the same group of amino acids which have elsewhere been shown to be essential for man, rat, and bovines.

(*e*) *Appetite.*—On diets of chaffed Wimmera ryegrass straw, chaffed wheaten straw, chaffed wheaten hay, lucerne chaff, or equal parts chaff and cracked maize, the daily addition of a quantity of the ration *per fistulam* resulted in a corresponding reduction in the quantity of feed voluntarily consumed, which suggests that factors other than palatability are largely responsible for feed-intake regulation. The rate of passage of straw through the alimentary tract has been found to be slower than rates reported for better-quality roughage. Although published data indicate that rate of passage and feed consumption may vary according to the state of subdivision of the feed, it was found that the consumption of wheaten hay was the same whether offered as ground material or as chaff.

11. Drought Feeding.

(Division of Animal Health and Production.)

Drought feeding experiments with sheep have been continued in collaboration with the New South Wales Department of Agriculture at the Veterinary Research Station, Glenfield. Financial support was again provided by the New South Wales Graziers' Association from the Burdekin Bequest Fund.

(*a*) *Utilization of Low-quality Roughage.*—In the fifth experiment on this aspect of drought feeding, groups of two-tooth Merino ewes and wethers were given free access to a basal ration of chaffed wheaten straw containing 2-5 per cent. crude protein, plus nitrogen supplements at twice-weekly intervals in the form of high protein meals, lucerne chaff, or wheat or oats plus urea. Satisfactory performances were achieved after 22 weeks under yard conditions with young Merino sheep when the roughage was supplemented with nitrogen in the form of palatable protein concentrates, or as urea plus high-energy low-protein concentrates such as wheat or oats. The mode of action of these supplements is being investigated in metabolism cages.

The sixth experiment has been designed to assess the effects of roughage quality on performance and to investigate further the value of urea as a nitrogen supplement.

(*b*) *The Influence of Plane of Nutrition on Breeding Performance of Merino Ewes.*—The performance of two-tooth Merino ewes during pregnancy and lactation is being studied at two levels of energy and two levels of protein intake, namely, 4 and 6 lb. starch equivalent and 10 and 16 per cent. crude protein. The higher level of nitrogen intake is being provided by the addition of urea to the basal ration which contains 10 per cent. crude protein.

(*c*) *Early Weaning of Merino Lambs.*—Data have been collected from four properties in the field on the survival rates, body weight changes, general performance, and plasma vitamin A levels of representative groups from approximately 4,000 Merino lambs weaned at 9-17 weeks of age. The results have demonstrated the success of early weaning in the field under severe drought conditions and have confirmed earlier experimental results in small yards.

12. Toxicity of Large Rations of Wheat.

(Division of Animal Health and Production.)

Attempts were made to reproduce the condition by increasing the water activity of the ruminal contents, by means of high concentrations of polyethylene glycol 4000, to levels comparable with those found after wheat gorging, and by combining this with high concentrations of lactic acid. Plasma volume was lowered 20 per cent. by this means, blood lactate rose to 85 mg/100 ml, and blood pH fell to 7.12; but death did not ensue. However, since in the wheat-gorging syndrome plasma volume commonly decreases 40 per cent. these experiments do not necessarily disprove the hypothesis that the condition is due to a combination of osmotic dehydration and alimentary lactacidosis. It was found that salivary secretion virtually ceased 6 hours after wheat gorging. The study of the role of the spleen as a reservoir of red cells in sheep, which was stimulated by anomalous increase of haemoconcentration during the course of the wheat feeding syndrome in intact sheep, was concluded by experiments with red cells labelled with radioactive chromium.

13. Infertility and Physiology of Reproduction.

(Division of Animal Health and Production.)

(*a*) *Effect of Nutrition during Pre-mating and Mating.*—At the Regional Pastoral Laboratory, Armidale, a total of 400 fine-wool Merino ewes were fed either a low or a high level of legume chaff and oat grain for 8 weeks before and 5 weeks during mating. Half the ewes in each group were switched to the opposite treatment after 6 weeks, i.e. 2 weeks before mating commenced. Best conception rates and lambing performances were in the switched groups, i.e. high-low and low-high groups.

(*b*) *Seasonal Variation in the Level of Fertility in Merino Sheep.*—The variable nature of reproductive activity of ewes in the spring has been examined by the Sheep Biology Laboratory for a further year, at Tooradin in Gippsland, where ewes from three sources have been gathered together. In Peppin ewes from Gilruth Plains and the Riverina sexual activity was lowest in November, while in non-Peppin ewes from Victoria it was lowest in September. The Riverina Peppins were less active sexually in 1957 than in 1956. Most ewes from each source mated within a month after they were joined with rams in early December.

There appears to be a higher incidence of oestrus, in November, in recently shorn than unshorn ewes, and it seems that the Victorian ewes might be responsive to stimulation by the rams for only a very short period in November.

(*c*) *Influence of Light on the Breeding Season of Merino Ewes.*—Factors other than duration of light play a part in the establishment and maintenance of seasonal variation in sexual activity in Merino ewes. Ewes born during May-June, 1955, have been subjected to continuous light from August, 1955; during 1957 they exhibited seasonal variation in sexual activity closely similar to that of ewes maintained in the normal light environment. Older ewes subjected to a day length of 12 hr. in artificial light have also exhibited seasonal variation in reproductive activity, which, except for a shorter period of ovarian inactivity, resembled that in ewes exposed to the normal seasonal variation in a day length either as artificial light or as natural daylight.

(*d*) *Effect of Nutrition during Pregnancy.*—Fine-wool Merino ewes at the Regional Pastoral Laboratory, Armidale, were wintered and lambed after either a high or a low level of nutrition over the first four months of pregnancy, on sown or native pastures. Wide differences were established in bodily condition before lambing, combined with either high- or low-plane pen feeding on legume chaff and oat grain during the last month of pregnancy. After lambing they were further divided into high-plane or low-plane feeding for six weeks, then run together on pasture. The nutrition in the first four months of pregnancy had as great an effect on lamb growth rate, weaning weight, and ewe wool production as did that over the first six weeks of lactation, and also had a substantial effect on lamb birth weight and perinatal mortality. Differential feeding in the last month of pregnancy considerably affected birth weight and lamb losses, but had only a minor influence on subsequent growth rate.

(*e*) *Infertility on Red Clover Pastures.*—Following reports of progressive reductions in lamb marking percentages and an increased incidence of dystocias and deaths when ewes grazed red clover dominant pastures, field observations were commenced in 1957. At the first lambing there was no increase in lambing troubles in fine-wool Merino ewes grazed on red clover during pregnancy as compared with similar ewes on pastures containing no red clover.

(*f*) *Lactation in Ewes.*—Observations were commenced by the Sheep Biology Laboratory on the pressure required to withdraw milk from the udder of the ewe in established lactation (6-20 cm. Hg in the preliminary observations) and the pressure applied by the newborn lamb in sucking (15-20 cm. Hg).

(*g*) *Physiology of the Neonatal Lamb.*—Following the observation in the field, that newborn lambs often cool very rapidly after birth, and may die as a consequence, the ability of newborn lambs to maintain body temperature under various conditions has been studied by indirect calorimetry. Heat production and rectal temperature were followed in a range of air temperatures, with and without wind, and with the coat both wet and dry. The newborn lambs from well-fed ewes were able to increase their heat production to maintain rectal temperatures even with the coat wet in a wind of about 10 m.p.h. at 8° C. Lambs from poorly fed ewes produced relatively less heat than those from well-fed ewes and their rectal temperatures commenced to fall under the more extreme conditions.

There was little difference between the behaviour of Merino lambs with the usual short birth coat and the few Corriedale, Border Leicester, and Romney Marsh lambs examined. However, Merino lambs with a long coarse coat were better able to conserve heat than the short-coated Merinos.

(*h*) *Factors Associated with Neonatal Mortality in Lambs.*—In a previous report, observations were recorded on the causes of death of newborn lambs in a flock of mature Corriedale ewes; in this flock maternal factors were relatively unimportant in contributing to deaths, no infectious agents were implicated, and all lambs artificially fed and kept warm from birth survived. Observations have now been extended to a flock of maiden Merinos in which maternal factors were likely to be important. Half of the ewes were not given any assistance at birth and were left in open yards with their lambs. Many lambs died (of 52 born six were stillborn and fifteen died within three days of birth). Maternal factors, in particular abandonment of the lamb at birth, were major factors contributing to death; no infectious agents were implicated. Ewes in the other half of the flock were assisted as required at birth, and were removed with their lambs to a warm shed soon after birth; lambs were artificially fed where necessary. All lambs, except one which died at birth, were alive and well three days after birth. These lambs grew significantly faster between birth and marking than the other lambs, although the ewes grazed the same pasture from three days after birth.

(*i*) *Effect of Husbandry Practices on Lamb Mortality—Lambing "Off Shears" and "In Wool".*—This investigation has continued at the Regional Pastoral Laboratory, Armidale. For a lambing commencing in early September loss of fine wool Merino lambs between birth and marking was 15 per cent. of lambs born in the "off shears" treatment and 17 per cent. in the "in wool" treatment. Lamb marking percentages were 71 and 72 respectively. Weather conditions were mild over marking.

(*j*) *Feed Intake of Suckling and Weaned Lambs on Dry Summer Pastures.*—Some preliminary observations have been made at the Sheep Biology Laboratory on the causes of poor growth in lambs after weaning. Feed intake (estimated by faecal dry matter output) of poorly grown, 16-week-old lambs, which had been weaned for two weeks, was slightly higher than intake by lambs which were still obtaining an estimated 6 oz. of milk daily from their dams. Under the conditions of the observations, the consumption of milk merely led to the suckling lambs eating less pasture.

(*k*) *Ewe-marking Crayon for Rams.*—This work is being undertaken to develop a simple, cheap, and practical method of determining which ewes mate. With the co-operation of the Wool Textile Research Laboratory, Geelong, a crayon has been developed which, under Victorian conditions, marks well, does not wear unduly, does not harden, nor glaze, nor pick up dirt, is simple and cheap to manufacture, and is simple to fix to the ram. Its reliability is being tested as a criterion of mating under field conditions.

14. Breeding and Genetical Studies.

(Division of Animal Health and Production.)

(*a*) *Inbred Flocks of Australian Merinos* (McMaster Feld Station).—Injection of highly inbred lambs with crude pituitary extract has resulted in increased growth rate to ten weeks of age by comparison with untreated inbred lambs. Continued treatment after ten weeks of age had no further effect. Wool production by treated lambs at weaning was significantly greater than that of the untreated lambs. Differences between the two groups in body weight and body size were still present at one year of age, but differences in fleece weight were very much reduced. Treatment of non-inbred lambs has had no effect whether from inbred but unrelated parents, or from simple outbreeding. The inbreeding syndrome appears to cause at least a partial reduction in the function of the pituitary gland.

Matings are in progress to explore the effects of inbreeding on maternal ability. It would appear that maternal ability of inbred ewes suckling single lambs is comparable with that of non-inbred ewes suckling single lambs.

(*b*) *Heredity × Environment Interactions* (McMaster Laboratory).—Preliminary comparisons of the mean greasy fleece weight of progeny of the same ram grown in two different environments (Cunnamulla and Armidale) indicated that marked reversals in ranking may occur in at least one of the two Merino strains used.

(*c*) *Selection of Individual Sheep.*—(i) *Comparison of Methods of Sire Selection for Clean Wool Weight (Part of Project AB1).*—Two groups selected for clean wool weight (S and MS), with a ceiling on wrinkle score and fibre diameter, are being compared with a random control (C). In one (MS) selection is on the ram's own measurements, in the other (S), his half-sibs are also considered. The prediction that this addition will not greatly increase annual genetic progress has so far been confirmed. Over the last two years, the mean clean wool weight for two-tooth ewes has been 11 per cent. above the control for the S and 8 per cent. for the MS group.

(ii) *The Effect of Selection for Clean Wool Weight on Efficiency of Wool Production.*—Four sires from each of the S, MS, and C groups were fed individually *ad lib.* for a period of 140 days. Mean wool production was in the ratio 126:118:100, under both grazing and *ad lib.* feeding, while the wool production per unit of food intake in the pens was in the ratio 120:106:100. There is thus no evidence that selection for wool weight has led to lowered efficiency.

(iii) *Comparison of Genetic Parameters for Rams and Ewes.*—Predictions of genetic progress based on genetic parameters estimated on females could be inaccurate if estimates on the male differed. Estimates of repeatability made on 10 characters in sheep indicate no sex differences. Estimates of heritability are now being made.

(iv) *Age for Selection in Sheep.*—Investigations confirm the efficiency of selection at two-tooth age, and selection even earlier may be possible.

(v) *Selection for Twinning in the Merino.*—Ewes selected as twin-bearers have now produced 5.2 lambs per head in four subsequent lambings, compared with 4.1 from ewes selected as single-bearers. Progeny of the twin-bearers have produced eight sets of twins and those of the single-bearers none, up to 2½ years of age.

(vi) *Selection for Mutton Characteristics in the Merino.*—A series of measurements to develop appropriate mutton scores from live measurements was made on 64 wethers in five Merino strains, before and after slaughter. Analysis is not yet complete. Matings for high and low mutton scores will be made.

(*d*) *Relationships among Clean Wool Weight and its Components; and Other Fleece Characters.*—(i) *The Influence of the Components on Clean Wool Weight.*—The influence of genetic and environmental factors on clean wool weight is being studied not only directly but through its components. A theoretical study has shown the extent to which the relative variances of the components and the correlations between them influence the relationship between wool weight and each component. Estimates now available indicate that these variances and correlations may vary between Merino strains, and such variation could account for the different conclusions which have been drawn by different workers.

Data from S and C mating groups have been used to analyse genetic (between groups) and phenotypic (within groups) relationships. Between groups, fibre number per unit skin area is of greatest importance in contributing to the 11 per cent. increase in wool weight, followed by staple length; body size is smaller in the selected group, while the other two "controlled" components show no change. Within groups, fibre number and staple length make equal contributions to differences between light and heavy wool weights, body size this time being slightly greater for the sheep with higher wool weights. Wrinkle score and fibre diameter again make little contribution.

(ii) *Selection for High and Low Values of Single Characters.*—To analyse these relationships further, pairs of families have been set up at Gilruth Plains in which selection is for a high or low value of a single character. Selection on clean wool weight itself has produced the greatest change in weight, though selection on clean wool weight per unit skin area has been nearly as effective. Selection for staple length, fibre number per unit skin area, or body weight has led to changes in the same direction in clean wool weight, but selection for fibre diameter or wrinkle score has produced no change.

(*g*) *Electrolyte Concentrations of Erythrocytes.*—The determination of K^+ and Na^+ concentrations of the erythrocytes of Merino sheep was made in progeny of the sheep previously examined. There seem to be strain differences in the incidence of high K^+ animals, more occurring in two medium Peppin groups than in a fine non-Peppin group.

(*h*) *Hornedness in Sheep* ("Gilruth Plains", Cunnamulla).—Further matings have been made in this experiment; some of them have been planned to yield information on the phenotypic differences between *PP* and *Pp* Merino males.

Observations are being made on the wool production of Merino sheep with different known genotypes as far as the triple alleles for hornedness are concerned. These alleles, whose effects were outlined in the previous report, have been named *P*, *P′*, and *p*, in decreasing order of dominance.

Mating programmes have been commenced which should indicate whether the horns of Dorset Horn ewes result from the gene *P′*, which initiates horn growth in Merino ewes, and whether the gene *P*, which produces polledness in the Merino, is also present in the Border Leicester breed.

15. Genetics of Sheep.

(Animal Genetics Section.)

The work on sheep has concentrated on two main problems: the role of follicle density in the determination of wool production, and the analysis of fleece structure in terms of discrete but interacting systems of determination. Two experiments involving selection on follicle development are progressing. The first, at the Dickson Experiment Station, has reached the second generation of selection on the number of secondary follicles per primary follicle. Although considerable differences of follicle density have been produced (approx. 20 per cent.), no differences of fleece weight could be detected. The second selection experiment, which has been initiated at Armidale, involves selection on the density of primary follicles. No data are available yet from this experiment.

The work on mosaics, although showing the general validity of the concepts of "competition" between follicles, has also shown that the determination of fibre length and diameter is extremely complex and that more detailed studies are required, particularly of the form and function of the follicle papillae. The work on the determination of the *N* type of fleece has been completed culminating in a series of papers. A notable achievement has been the extension to sheep of Nay's quick method of cutting sections of cattle skin. The result has been a dramatic decrease in the limitations imposed by laboratory facilities. The method has the advantages, not only of being faster than the usual histological procedures, but also of not needing highly trained technical staff.

16. Biological Studies of Skin and Wool Growth.

(Division of Animal Health and Production.)

(*a*) *Endocrinology of Wool Growth* (Sheep Biology Laboratory, Prospect).—(i) *Wool Growth and the Anterior Pituitary Gland.*—Work is continuing on the isolation and identification of the anterior pituitary hormones responsible for the maintenance of wool growth as described in the last Annual Report. The use of cellulose acetate filter membrane and starch gels for analytical zone electrophoresis of pituitary protein mixtures has been developed. The distribution of hormones in the various kinds of intracellular pituitary particles is being investigated, and this information is being used in the preparation of the different pituitary hormones.

(ii) *Wool Growth and the Adrenal Cortex.*—The importance of the adrenocortical secretion in determining the wool growth rate of sheep is being studied in adrenalectomized sheep maintained with different dosages of adrenocortical steroids. Wool growth is inversely related to the maintenance dose of adrenocortical steroids.

(iii) *Wool Growth and the Thyroid Gland, Prospect.*—Earlier work has shown that injections of sodium-L-thyroxine into normal sheep stimulates wool growth by increasing feed intake and by decreasing the storage of body tissues. There is consequently no increase in the efficiency of conversion of feed protein into wool. However, a minimal degree of thyroid activity is necessary for normal wool growth and for the action of pituitary hormones. The influence of thyroxine on wool growth in the hypothyroid range is being studied.

(iv) *Wool Growth and the Thyroid Gland* (Regional Pastoral Laboratory, Armidale).—A total of 370 fine-wool Merino wethers in groups of 20-30 were treated with thyroxine, and their wool production and liveweight changes measured under a wide range of typical grazing conditions. Single implants of 60 mg. thyroxine gave about 8 per cent. increase, and repeated implants of 30 mg. gave 10 per cent. increase in six months' wool clip with no permanent reduction in liveweight. Repeated treatments with 60 mg. gave up to 15 per cent. more wool, but liveweight was reduced by 10 lb. Repeated treatments with 90 mg. gave 17 per cent. more wool, and liveweight was reduced by 12-15 lb. Deaths occurred where the effect of the thyroxine treatment was increased by inadequate nutrition.

(*b*) *Studies of Skin and Fleece Development* (Sheep Biology Laboratory, Prospect).—(i) *Effects of Lamb Nutrition.*—A series of observations on the effect of nutrition during pre- and early post-natal life on the development of the follicle population and on the juvenile and adult wool production of Merino sheep has now been completed, and the results are being analysed in preparation for publication.

(ii) *Lamb Birth and Adult Fleece Characters.*—Observations are being continued to determine whether there is a differential response to primary and secondary follicles to changes in the plane of nutrition, and particularly to what extent this response may be affected by the genetic background which causes differences in primary and secondary fibre size.

(iii) *Mitotic Rates in the Wool Follicle Bulb.*—Techniques are being developed for determination of mitotic rates in the follicle bulb in order to study the association between mitotic rate and fibre size, and the influence of physiological (nutritional, endocrine, and genetic) factors on mitotic rate.

(iv) *The Post-natal Development of Wool Follicles.*—The quantitative study has continued of the post-natal growth and development of wool follicles in Merinos and Southdown-Merinos. The changes in ratio of secondary to primary follicles and fibres, and the number of follicles and fibres per sq. mm., have been examined in these sheep up to the age of nine months; observations will be continued until the sheep are adults.

(v) *Effect of Nutrition on the Skin and Wool Follicles.*—A study of the effect of nutrition on the skin and wool follicles in Merino wethers at the Burdekin Drought-feeding Unit, Glenfield, was commenced during December, 1957.

Five groups, each of five sheep, were selected from 18 different groups in an experiment on the utilization of low-quality roughage (see this chapter, Section 11). The sheep selected belong to groups expected to give the poorest and best results. To date, only one sheep has died. All sheep are weighed weekly and skin samples are taken every fortnight. At each sampling the thickness of the skin is measured with callipers. The plane of nutrition has a significant effect on the thickness of the skin.

(*c*) *Fleece Structure and Wool Production.*—(i) *Interrelations of Fleece Components.*—Extensive data derived from a collection of skin samples taken from unclassed groups of maiden stud ewes of most breeds of sheep present in Australia, and from side progeny groups in one Merino stud flock, have been analysed by using the electronic digital computer (SILLIAC) at the University of Sydney. In particular, correlation and heritability studies indicate that number of follicle groups per unit area of skin may be more closely related to wool production per unit area of skin than is total follicle density. Further, genetic variation of area of fibre per unit area of skin has not been utilized by customary methods of selection in the development of different fleece types.

(ii) *Fleece Mosaics.*—These unique fleece types continue to be used in comparative investigations of the interrelations of the metrical components of wool production and their underlying biological determinants.

The embryological and genetic bases of fleece mosaicism have been investigated by breeding mosaics "*inter se*" and with normal fleece types, by examination of the patterns of mosaicism, by measurement of the areas of abnormal tissue (fleece), and by preliminary cytological studies of skin and gonad tissue. Fleece mosaicism results from an underlying genetic mosaicism of the skin which is due to aberration of the mitotic division of an early embryonic skin cell.

The patterns of distribution of the areas of abnormal amongst the normal skin tissue indicate that from a single aberrant mitosis, viable abnormal skin cells move and intermingle with normal cells, first in anteroposterior directions along the mid-dorsal line, and later, without further intermingling, migrate more or less symmetrically and dorsoventrally. Similar skin growth patterns may be responsible for the arrangement of the major skin folds of Merino sheep.

(iii) *Skin Grafting.*—Preliminary studies have been made of the disposition of foetal membranes in sheep at the early stages of gestation as a preliminary to skin homografting and other surgical manipulation of foetal skin tissues.

Investigations with mice have shown that the incompatibility of the homografts of male on female skin is not a universal phenomenon but varies considerably between strains within inbred lines as well as between inbred lines. Extensive trials of methods of abrogating the skin homograft reaction in adult mice—as a preliminary to sheep work—by injection of skin extracts by various routes and by sequential grafting have failed to confirm overseas claims.

(iv) *Skin Stretching.*—Altering the spatial relations of wool follicles by surgical removal of skin from lambs in early post-natal life has modified local fleece structure at 1½ years of age. By comparison with control regions, fibre diameter has increased, fibre length growth rate has decreased to a variable extent, and follicle density has increased, which indicates that no new secondary follicles were initiated post-natally in response to the wider separation of existing mature and developing follicles.

(v) *"Doggy" Wool.*—Since the classing of Merino wool as either "normal" or "doggy" is a subjective assessment, measurements were performed on wool and skin samples from sheep of similar breeding to compare these two types of wool. Differences were observed in staple and fibre crimping, in that the doggy wool had fewer crimps per inch than the normal wool. For medium-wooled Merinos the mean fibre thickness of the doggy wool was larger than that of the normal wool, whereas for strong-wooled Merinos the mean fibre thicknesses were similar. The staple lengths of the doggy and normal wools were also similar, but there was some indication that the average fibre length of the doggy wool was slightly shorter. Little or no difference could be found in the characters examined from skin samples. Some fine-wooled Merino ewes with doggy or normal wool, obtained from the Regional Pastoral Laboratory at "Chiswick", will be used for further studies of fibre structure and of the effect of level of nutrition.

Preliminary cytological examinations of skin tissues from a Merino mosiac revealed an obvious difference in cell and nucleus size between the cells of follicles and glands in normal and abnormal regions. These observations are being extended to all available mosaics and to fibre and gonad cells.

(vi) *Fleece Mutants.*—Four families of fleece-type mutants are being studied; in Merinos, low density, lack of sweat glands, and felting lustre, and a carpet fleece-type in both the Southdown and Corriedale breeds.

Further evidence on the inheritance of these unusual fleece types is being gathered in the course of studies of these new combinations of the biological determinants of fleece structure.

(*d*) *Relation of Wool Growth to Feed Intake.*—(i) *Efficiency of Wool Growth.*—For biological purposes the efficiency of wool growth may be defined as the proportion of the crude protein intake converted into wool. An equation has been developed relating the efficiency of wool growth to the rate of body weight change. At maintenance-feed intakes when body weight change is zero, the efficiency of wool growth has a value characteristic of the individual and the time of year. At feed intakes below maintenance, efficiency is increased by the contribution of nutrients from the catabolism of body tissues. At intakes above maintenance, efficiency is decreased by the diversion of part of the crude protein intake to an increase in body tissues. Analysis of available data suggests that the average efficiency of wool growth of a sheep on a feed intake which is at first above maintenance and later below maintenance is the same as the efficiency of the same sheep maintained throughout on the same average intake kept constant. The effect of the crude protein percentage in the diet on the efficiency of wool growth is being examined.

Observations in the laboratory are continuing on these groups of sheep ranked as having high, intermediate, and low wool production per unit of body weight under field conditions. The animals were first rationed according to body weight and subsequently allowed *ad lib.* intakes of the ration. A relatively large proportion of the variability in production under field conditions is referable to variations in feed intake.

(ii) *Effect of Variations in the Plane of Nutrition on Metric Characters of the Fleece.*—The response of the metrical characters of the Merino fleece to changes in feeding level has been studied in a group of eight sheep, previously maintained on an *ad lib.* diet from birth to two years. This group has been subjected to successive decrements in ration, culminating in severe nutritional stress, and maintained at the lowest level until equilibrium of various characters had been achieved. This has been followed by a renewed course of *ad lib.* feeding. Wide individual differences have been apparent, and it is clear that a small proportion of animals are much less responsive to nutritional stress, in terms of body weight changes as well as fleece changes.

Changes of fibre diameter amongst the more responsive animals are of particular interest. At restricted feed levels mean fibre diameter decreased rapidly and then, in some cases, rose appreciably towards the value achieved on *ad lib.* feeding. In these cases a proportion of the secondary follicles has been quiescent, and a number of the primary follicles are in intermittent production. These primary follicles are responsible for the small number of very coarse and medullated fibres which now appear in the diameter distribution beyond the range found at high feed levels.

(*e*) *Estimation of Total Fibre Number* (McMaster Field Station).—An adequate estimate of total fibre number can be obtained by dividing clean fleece weight by mean fibre weight. Mean fibre weight was constant over the body of the sheep including the belly. A single mid-side sample is sufficient to provide a satisfactory estimate of fibre weight.

Mean fibre and staple length exhibited a small but distinct trend over the body. There is a decrease in an anteroposterior direction, and also dorsally and ventrally from the midside. There is no sharp distinction between body and belly regions in fibre length, but staple length is much shorter on the belly.

17. SHEEP DISEASES.

(Division of Animal Health and Production.)

(*a*) *Jaundice in Sheep* (Animal Health Laboratory, Melbourne).—Research at this Laboratory has already revealed two major causes of jaundice in sheep in Australia. These are chronic copper poisoning and heliotrope poisoning.

(i) *Chronic Copper Poisoning.*—In laboratory studies relating to phytogenous chronic copper poisoning, due to the ingestion of usual pasture plants but resulting in storage of copper in the liver in dangerously high amounts, the part played by other trace elements in the interrelationship between molybdenum and copper has been investigated. Evidence has been obtained which indicates that the limitation of copper storage imposed by molybdenum and inorganic sulphur is subject to interference by manganese. Also, in seeking for factors likely to account for large individual variations in copper storage among sheep subject to the same experimental conditions, endocrine studies have been commenced. No relationship could be demonstrated between the degree of thyroid gland activity and the amount of copper stored.

(ii) *Heliotrope Alkaloids.*—The repeated ingestion of *Heliotropium europaeum* has already been shown to be a primary cause of death in sheep following a liver damage by the plant alkanoids. Non-haemolytic jaundice is a common sign of this condition. The chemical pathology of poisoning with these alkaloids is being studied, mostly in experiments with rats (see Chapter V., Section 11). Heliotrope can also be the cause of hepatogenous chronic poisoning in sheep. This hepatogenous form is so named because liver damage by the alkaloids is a pre-requisite for liver storage of copper at the high levels that may lead to haemolytic jaundice. It can occur with diets, whether natural or artificial, which would not of themselves be harmful. In the general study of the effects of these pyrrolizidine alkaloids on rats, observations are also being made on the storage of copper by the damaged liver.

(iii) *Enzyme Pathology* (McMaster Laboratory).—Research into the toxicity of alkaloids from *Heliotropium* spp. has revealed *in vitro* inhibition of enzyme systems of the liver. Lasiocarpine is more inhibitory than heliotrine and each is much more inhibitory than the respective *N*-oxide. The precise locus and mode of inhibitory action is being sought.

(*b*) *Posthitis* (Regional Pastoral Labatory, Armidale).—Observations were continued on the incidence and course of untreated posthitis in a flock of wethers two-three years old. The incidence of external and internal ulceration was related to seasonal changes in pasture growth and composition, e.g. cases of internal ulceration increased during the autumn flush and decreased during winter and early spring when dry conditions prevailed. Some progress has been made in the development of a self-retaining sheath tube for the treatment of the condition.

(*c*) *Mycotic Dermatitis* (McMaster Laboratory).—Studies have been made on the life-cycle of the causal organism *Nocardia dermatonomus*. The formation of a branched mycelium occurs during invasion of the stratum corneum of the skin and requires a relatively high temperature, low Eh and pO_2, and abundant nutrients. Progress was made in inducing artificial infections for screening of curative agents, but no agent yet tested has been found satisfactory.

Continued dry weather hampered field experiments on the spread of the disease from ewe to lamb.

(*d*) *Footroot.*—A simple medium consisting of ground sheep horn in lemco agar has been evolved for the culture of the causal organism *Fusiformis nodosus*, and has proved of great value for accurate diagnosis. Good growth was also obtained in acid hydrolysed horn plus "Difco" trypsin. Paper chromatography has been used to determine the amino acids present in the medium.

The efficiency of several additional chemical agents was tested on affected feet, but none has proved as efficient as 10 per cent. chloromycetin. The organism is less susceptible to erythromycin than to chloromycetin.

Sustained dry weather hampered field experiments on the epidemiology of the disease.

(*e*) *Foot Abscess.*—A selective medium has been devised for the isolation of *Fusiformis necrophorus* from highly contaminated material.

A field trial to observe the incidence of foot abscess in normal and cracked hooves and to assess the effect of paring was unsatisfactory owing to prolonged dry conditions.

(*f*) *Brucellosis of Sheep* (Animal Health Laboratory, Melbourne).—In small experiments to test the ability of the udder of the ewe to harbour *Brucella ovis*, suspensions of virulent organisms were introduced by different routes. By direct introduction via the teat canal the organism became established earlier than via the conjunctival sac or the jugular vein. In all cases the infection, when once established, persisted for several months.

In view of the availability of preventive vaccines containing living *Br. abortus*, strain 19, which is of reduced virulence for cattle, some rams were inoculated by various routes to determine virulence and the likelihood of locating in the genitalia. Only direct inoculation into the testis or epididymus led to the establishment of infection of the genitalia. In some instances the organism was then excreted in large numbers in the semen for a period of more then seven months.

(*h*) *Pregnancy Toxaemia* (McMaster Laboratory).—A study of enzymes of the sheep has shown that, as distinct from non-ruminants, its liver does not metabolize glucose owing to the absence of glucokinase. Glucose is used upon addition of hexokinase. This places particular emphasis on fatty acid oxidation in liver metabolism.

In pregnancy toxaemia there is a failure of liver fatty acid metabolism, amounting to liver failure. The syndrome of pregnancy toxaemia can be explained by this finding. Investigation of the fatty acid oxidation block is progressing.

Hydroxycortisone has been found to inhibit oxidation of various substances including fatty acids by complex formation between the steroid and coenzymes, thus removing coenzymes. Inhibition can be prevented by addition of requisite enzymes.

(*i*) *Urinary Calculi.*—A preliminary survey of the incidence of urinary calculi in wethers in the west Darling district has revealed an association with grazing on lush herbaceous pastures.

18. INTERNAL PARASITES.

(Division of Animal Health and Production.)

(*a*) *Studies in Anthelmintics.*—(i) *At McMaster Laboratory.*—Sheep grazing dry pastures were dosed with phenothiazine after 24 hours without water with no untoward effects.

Phenothiazine with 90 per cent. of particles less than 10μ was less effective against *Ostertagia* spp. than against *Trichostrongylus colubriformis* in sheep.

Three organic phosphorus compounds have been tested. *O*, *O*-dimethyl hydroxy-2,2,2-trichlorophosphonate (Bayer " L13/59 ", " Neguvon ", " Dipterex ") at 2.5 g./100 lb. body weight was usually highly effective against *Haemonchus contortus*, but occasionally there was only a temporary reduction in worm egg count. Doses of 5.0 g. into the abomasum were effective against *T. colubriformis*, but 10 g./100 lb. body weight into the rumen was ineffective. Efficiency against *Oesophagostomum columbianum* was variable even at dose rates which were fatal to some sheep. 3-Chloro-4-methyl-7-oxycoumarine diethyl thiophosphoric acid (Bayer " L21/199 ", " Muscatox ") was highly effective against *H. contortus*, *T. colubriformis*, *T. axei*, and *Oe. columbianum*, but is too toxic for general use. *O*,*O*-dimethyl-*O*-2,4,5-trichlorophenyl phosphorothioate (" Dow-ET ", " Trolene ") was the least effective of the three.

Oil of mustard showed moderate anthelmintic activity but was toxic at 0.75 ml. The essential oils of spearmint, carraway, sassafras, aniseed, and cassia were ineffective against *H. contortus* when 30 ml. were given into the rumen. Similar doses of carvone, safrole, anethole, cineole, and piperitone were also ineffective.

Copper methyl arsenate (" Monekil S ") is very effective against *Moniezia* spp., but in non-toxic doses was only slightly effective against *H. contortus* and *Oe. columbianum*.

Di - (*N* - benzyl - *N*,*N* - dimethyl - *N*-2-phenoxymethylammonium)-3-hydroxy-2-naphthoate was very effective against *H. contortus* and *Oe. columbianum* when injected into the rumen, but not against *T. colubriformis* unless given into the abomasum. Butyl-*N*-phenyl thiocarbamate showed anthelmintic activity against *T. colubriformis* (8 g./100 lb. body weight into the rumen).

3,3-Diethylthiadicarbocyanine iodide (" Dithiazanine ") showed fair efficiency against *T. colubriformis* (9 g./100 lb. body weight into the rumen). Further trials with papain, dosed into the abomasum, were unsuccessful against *T. colubriformis*. Doses of 0.1 g. promethazine hydrochloride or 0.15 g. diethylamine-*N*-phenothiazine hydrochloride into the rumen were not effective against *T. colubriformis*.

In tests of anthelmintic activity against the oxyurid worms of mice, Bayer " L13/59 " was highly effective at 0.5 g./kg. body weight. Pyridine was effective at 0.25 g./kg. body weight but was fatally toxic in two of six mice. The essential oils of spearmint, aniseed, sassafras, cassia, juniper, and mustard were ineffective, as were also the active principles, safole, menthol, sabinol, and carvone. Oil of Cananga showed slight activity. 2,6-Lutidine and 2-amino-3-chloropyridine were ineffective at 0.5 g./kg. and toxic at 1.0 g./kg. body weight. 2-Pyridyl phenylamine and 2,2-dipyridylamine were inactive at 2 g./kg. body weight. 10-Allyl phenothiazine showed moderate activity at 2 g./kg. body weight. Carbon bisulphide was not effective, but toxic, at 2 g./kg. body weight. Phenothiazine at 2 g./kg. body weight of very fine particle size (50 per cent. less than 2 microns) gave the lowest efficiency yet experienced with this compound.

The indices of chemical compounds of interest in helminthology were completed.

(ii) *At Regional Pastoral Laboratory, Armidale—Phenothiazine-salt lick.*—Breeding ewes grazed at four and eight per acre on sown pastures were provided with a 1 : 12 mixture of phenothiazine and salt; control groups of ewes had access to salt.

Since November, 1956, when the experiment commenced, climatic conditions have not favoured parasitic infestation, worm egg counts have been low, and no differences in egg counts, due to rate of stocking or to the provision of phenothiazine, have developed. However, there is evidence that the intake of phenothiazine, which since May, 1957, has varied from 0.3 to 1.0 g. per head, is sterilizing a proportion of worm eggs and thereby reducing pasture contamination. No staining of wool with phenothiazine was observed.

Piperazine.—Daily prophylactic doses (0.5 g.) of piperazine given concurrently with infective larvae of *Oe. columbianum* did not prevent the establishment of larvae in intestinal nodules or the subsequent development of adult worms.

" *Neguvon* " (*O*, *O-dimethylhydroxy-*2,2,2*-trichlorophosphonate*).—This organic phosphorus compound was administered to weaners at rates of 2.5, 5, and 10 g. per 100 lb. liveweight by injection into the rumen and by mouth after swabbing with 10 per cent. copper sulphate solution. No ill effects were observed in sheep given 2.5 g. or 5 g. per 100 lb. by mouth but the 10 g. rate was rapidly fatal in two of ten sheep and affected three others. The 10 g. dose injected into the rumen produced no signs of toxicity.

(*b*) *Effect of Nutritional Level on Infestation* (McMaster Laboratory).—The administration of vitamin A to sheep with low plasma levels did not affect their susceptibility to the establishment of *T. colubriformis*.

There was no difference in susceptibility to the establishment of 50,000 *T. colubriformis* larvae between worm-free sheep ten months of age fed *ad lib.* wheat 50, wheaten chaff 30, and lucerne chaff 20 parts and those fed the same mixture but at half the quantity.

The infested sheep on the full ration showed a decline in appetite from 2 lb. per head per day to 1.4 lb. in a month, and to 0.8 lb. in two months, and the minimum intake was 0.4 lb. three months after infestation. It was observed that whereas the adverse effects of the original infestation occurred rapidly in the poorly fed group, their onset was delayed for several weeks in the previous well-fed group and then seemed to be associated with the marked decline in food intake.

(*c*) *Epidemiology*.—Lambs in Tasmania show gradually increasing numbers of worms from September, reaching a peak in November or early December, followed commonly by a decline and a rapid rise from early January with sustained high levels of infestation until early May when there is an abrupt decline. Greatest worm burdens are usually in February-March.

Preliminary observations at three localities in Victoria showed that lambs born in the spring may harbour heavy infestations with *Ostertagia* spp., *Trichostrongylus* spp., *Nematodirus* spp., and *Trichuris* spp. by early summer, and infestations with *Oe. venulosum* and *Chabertia ovina* tend to increase somewhat later.

A method has been developed to recover and count larvae from rumen contents and thus assess the number ingested by grazing sheep. Eggs of *Ostergia* spp., *T. axei*, and *T. colubriformis* will withstand storage at 4° C. for 168 hr., whereas the eggs of *H. placei* were dead after 24-48 hr., those of *H. contortus* at 96 hr., and those of *Oe. columbianum* at 48-72 hr. A new technique has been evolved which permits the differentiation of first stage larvae of sheep nematodes.

(*d*) *Resistance and Immunity to Nematode Infection.*—There was no evidence that repeated treatments with phenothiazine interfered with the development of resistance to *T. colubriformis.* Control lambs, exposed with the treated lambs to natural infestation from birth, remained susceptible until about nine months of age.

The direct sensitizing ability for red cells of various fractions of *H. contortus* larvae was investigated, but none was satisfactory. Sensitization of cells with antigen after treatment with tannic acid allowed a haemagglutination test to be used in parallel with the complement fixation test. No constant relationship exists between the results of the two tests.

Agar gel diffusion reactions have been used to investigate the antigenic character of *H. contortus* and *T. colubriformis* larvae by using sera from infested sheep. Preliminary results have established a qualitative difference between the antisera to these species. The antigens of excretory products and exsheathing fluid of larvae are present in antigens prepared from whole larvae.

(*e*) *The Exsheathment of Nematode Larvae.*—Infective larvae of some species of ovine trichostrongylid nematodes exsheath in the rumen of the sheep, but there is no evidence that exsheathment is stimulated by a specific substance. A wide range of substances, many of which are present in the rumen, can influence the process, e.g. sodium chloride, calcium chloride, and acetic acid, but only under specified physical conditions, which include a limited range of temperature and hydrogen ion concentration, as well as low oxidation-reduction potentials. These are important in the initial stages of exsheathment. Oxidation-reduction potentials appear to act directly on the larvae, possibly conditioning some centre which appears to be located in the vicinity of the posterior half of the oesophagus. Mechanisms for storage and release of exsheathing fluid are probably also located in this region.

(*f*) *Chemical Studies.*—Substituted phenothiazines have been synthesized by a new process. Substituted 2,2′-dinitrophenyl sulphides were treated with hydrazine in the presence of alkali. One of the nitro-groups is selectively reduced, and a Smiles rearrangement and a ring closure takes place to give the phenothiazine in good yield. Phenothiazine, 2,7-dichlorophenothiazine, and 1,6-dichlorophenothiazine have been prepared by the selective reduction process.

The absorption and excretion by sheep of various particle sizes of phenothiazine were investigated. Attempts were made to prepare pyridine analogues of phenothiazine.

(*g*) *Liver Fluke.*—Studies on *Simlimnea subaquatilis,* the snail intermediate host of *Fasciola hepatica,* included observations on habitats, growth, reproduction, aestivation, migration, and food and oxygen requirements. One generation can be completed in one month. Eggs can hatch five days after oviposition and the resulting snails can produce eggs in 27 days. Oviposition appears to depend on environmental conditions and is not restricted to any one season of the year. Snails may aestivate in dried mud for at least 77 days. The maximum number of eggs recorded from a single snail in one month was 239. Eggs in egg masses were killed by both copper sulphate and copper pentachlorophenate (10 p.p.m.) after exposure for only 15 min.

Copper pentachlorophenate has proved to be a more effective molluscicide against *S. subaquatalis* than copper sulphate. It is formulated as a 30 per cent. dispersible paste and applied by high volume spray at the rate of 10 lb. per acre in 400 gal. of water by means of a boom spray and lance coupled to a bushfire fighting pump. The removal of vegetative cover and the institution of effective drainage of springs and swamps are also necessary. The snails can survive dry periods for some months, and spraying is best carried out when there is ample surface water.

The intramuscular injection of carbon tetrachloride into cattle appears to be a safe and effective therapy for the control of fascioliasis.

19. EXTERNAL PARASITES.

(Division of Animal Health and Production.)

(*a*) *The Ecology and Control of Lice Populations* (McMaster Laboratory).—The study has been completed of the influence of temperature and humidity on louse populations. Temperatures between 33 and 36° C. were required for the optimum rate of increase of *Linognathus pedalis.* Skin temperatures of the limbs of sheep are very variable and may remain below the optimum requirements for *L. pedalis.* A study is being made of certain aspects of the reproductive physiology of lice. Preliminary experiments with the tip-spray and with the dusting techniques using dieldrin to control lice appeared satisfactory.

(*b*) Psorergates ovis.—Field trials with 0.025 and 0.05 per cent. diazinon failed to control *P. ovis,* whereas 0.2 per cent. arsenic was successful. Further trials are in progress to compare the efficiencies of lime-sulphur and arsenic. Studies on the bionomics of itch mite were continued.

(*c*) Ixodes holocyclus.—No significant difference was found in specific cholinesterase activity of erythrocytes or of diaphragm homogenates between mice paralysed by *I. holocyclus* and controls.

20. SHEEP BLOWFLIES.

(Division of Entomology.)

An ecological study has been commenced in the Australian Capital Territory on the diurnal, seasonal, and regional variations in abundance of blowflies. Diurnal fluctuations in activity of the various species show remarkable parallels to the curves of variation in abundance with season. Most species became scarce in the study area during a long dry period in January and February; but after a substantial fall of rain the population increase was far too rapid to be accounted for by local breeding. Flies reinvaded the area from habitats where they had been sheltering during the drought. This strong presumptive evidence of large-scale rapid population shift indicates that blowfly population dynamics must be considered on a very broad geographical basis.

The overwintering of the sheep blowflies in the Canberra area is also under investigation. Adults of *Chrysomya rufifacies* emerge from carcasses until late autumn, whenever temperature conditions permit. At this time very few primary flies emerge, although this group in general is better adapted to cooler conditions than *C. rufifacies.* In a study of diapause in *Lucilia sericata* it was found that females trapped at intervals throughout the season gave no diapausing progeny until mid-March.

Studies with carrion have strongly reinforced early observations that carcasses of different kinds of animals may produce widely differing assortments of blowflies.

21. OTHER SHEEP INVESTIGATIONS.

(Division of Animal Health and Production.)

(*a*) *Clover Oestrogens* (Department of Agriculture, Perth).—In continuation of the work with clover chloroplasts, gradient elution chromatography from silica gel has proved very useful for removing some of the inactive phenols but, so far, the oestrogenic substance has not yet been isolated.

22. CLIMATE PHYSIOLOGY OF THE SHEEP.

(Division of Animal Health and Production.)

(*a*) *Equipment for Climatic Research* (Sheep Biology Laboratory).—Tests have been made on the climatic chambers and improvements carried out. They can now be operated at climates outside the range for which they were originally designed. Simple equipment, to simulate wind and rain, has been completed and calibrated. A wind tunnel for more accurate work is being built. Two light-tight rooms have been built for use in experiments on seasonal variation in wool growth. By using simple accommodation of this kind it is possible to conserve the climatic chambers for work which needs their elaborate facilities.

The engineering and design experience of the Climatic Section and workshop staff have been used to make an inexpensive climatic chamber at the McMaster Field Station, Badgery's Creek, for use in studying the heat tolerance of cattle. It is designed to produce climates with any temperature and absolute humidity above ambient.

(*b*) *Cold Stress after Shearing.*—The object of this work is threefold: (i) To find the combinations of weather conditions most likely to cause losses after shearing, by constructing a scale of "effective temperature", integrating temperature, air movement, and rain; (ii) to investigate methods of alleviating cold stress; (iii) to find whether immediately after shearing, the sheep is especially susceptible to hypothermia, irrespective of the length of wool.

The first essential is to find a measure of cold stress. This in man, and probably most large animals, is difficult. Skin temperature, the most commonly used index, is for theoretical reasons particularly unreliable in experiments involving varying amounts of wind and rain, and this seems to be the case in practice. Rectal temperature falls only in extreme cold stress, and then often precipitately. In milder conditions there can be a paradoxical rise lasting many hours. It has, however, been found that the heart rate increases in all degrees of cold stress, reaching a value around 140 beats/min. in extreme conditions.

At 37° F. with a wind of 7 m.p.h. and a rainfall of about ¼ in. per hr. newly shorn Merinos can become severely hypothermic in 3-4 hr.

(*c*) *Seasonal Effects on Wool Growth and Reproduction.*—It is now well established that wool grows faster in summer than in winter even under controlled nutritional conditions. In the past lack of specialized equipment has hindered the study of the relative importance of day length and thermal conditions in causing this variation. A simple experiment has been set up to examine this question with Merino and Southdown ewes. It is planned to follow skin thickness changes during this experiment. The suitability of various methods of measurement is being examined.

The experimental conditions of this study will provide the material for an examination of the breeding season of Australian Merino sheep in a high "light latitude" compared with that of a British breed, the Southdown. In addition, it will be possible to examine whether, in the absence of a "day-length signal", the breeding season can be controlled by seasonal variations of temperature.

Measurements are being made of vaginal volumes. These suggest that during the breeding season the vaginas of Merinos are several times larger than those of Southdowns. Changes between anoestrum and the breeding season and during the individual dioestrous cycles are also being studied.

(*d*) *Diurnal Rhythms.*—To interpret results of experiments involving climatic stress, it is necessary to know normal body temperatures at different times of the day and night. It was found that with 24 hr. lighting and a constant room temperature (80° F.), the rhythm depended only on feeding. The body temperature and heart rate rose after feeding and then fell slowly until the animals were fed again.

(*e*) *Sweating.*—The sweat production under heat stress in sheep of five breeds was examined by the desiccating capsule method. Only small amounts of sweat were produced, and in some instances no sweat at all. Preliminary observations emphasize the importance of panting as opposed to sweating in the cooling mechanism of the sheep. Earlier work showing that sheep sweat after both intradermal and intravenous injections of adrenalin was confirmed.

VIII. CATTLE.

1. GENERAL.

The cattle industry is the second major pastoral industry in Australia, and can benefit as greatly from the application of scientific research as the complementary sheep and wool industries.

The Organization has made a broad approach to the problems in this field, after first instituting a survey of the structure and interrelations of the various sections of the beef cattle industry throughout Australia. Current investigation includes: the elimination of loss from disease in both beef and dairy cattle; improvement of nutrition by the development of sown pastures; better management of natural pasture; and development of systems of breeding designed to evolve more productive beef and dairy types for northern Australian conditions.

The Organization's work on cattle problems has been carried out chiefly by the Division of Animal Health and Production, at the Animal Health Laboratory in Melbourne, the National Cattle Breeding Station at "Belmont", near Rockhampton, Queensland, and the Veterinary Parasitology Laboratory in Brisbane, Queensland (see Sections 2,3,4,6,7, and 8 of this Chapter). The Division of Entomology has been concerned with work on the cattle tick (see Section 5 of this Chapter). The work of the Division of Plant Industry on pastures is also of great importance to the cattle industry (see Chapter III). The work of the Animal Genetics Section on beef cattle is described in Section 9 of this Chapter.

2. Cattle Diseases.

(Division of Animal Health and Production.)

(*a*) *Pleuropneumonia of Cattle.*—Research in this field has continued at the Animal Health Laboratory, Melbourne. Concentrated suspensions of formalin-killed organisms, injected at the tail tip, gave rise to a considerable resistance to subsequent challenge by subcutaneous inoculation of virulent culture. The level of resistance was much inferior to that after living standard vaccine. The use of identical twin cattle yielded no evidence that genetic factors are of primary importance in susceptibility to bad tail reactions after living vaccine. Homozygotes tended to develop similar levels of agglutination reaction but not CF reaction, and to behave similarly as regards development of immunity to inhalation challenge. There was no significant tendency for unvaccinated homozygotes to be equally susceptible to inhalation infection. The study was concluded of joint and heart lesions in very young calves after tail inoculation with living vaccine, and it was demonstrated that these complications also followed intravenous inoculation. Progress has continued on freeze drying of standard vaccine, and recoveries of about 10 per cent. after reconstitution were commonly obtained. Factors influencing the growth of the organism in chick embryos were studied and a laboratory trial of " egg vaccine ", prepared according to Piercy's method, gave encouraging results. In the dried state the vaccine had high viability, but after reconstitution it became very susceptible to high ambient temperatures. An indirect haemagglutination test was developed for measuring antibody and antigen. A non-pyrogenic polysaccharide based upon galactose was isolated from the causal organism and was shown to sensitize red cells to this test in high dilution. Pleuropneumonia ribonucleic acid and its depolymerization were investigated and further progress was also made on the nutrition of the causal organism. During the year 703,675 doses (0.5 ml) of standard vaccine were issued for use in the field, and sufficient complement fixing antigen to test 44,000 cattle was donated to authorities in Australia and Kenya.

(*b*) *Brucellosis of Cattle.*—The investigation has been concluded of the duration of immunity following vaccination with *Brucella abortus* strain 19. Future work on brucellosis will be confined to relevant problems arising during the general study of infertility in cattle.

(*c*) *Infertility in Cattle.*—Causes of infertility of an infectious nature are being assessed. There is further evidence that the venereal disease of vibriosis is a serious cause of infertility in dairy herds in Victoria and that trichomoniasis is comparatively of little importance. A diagnosis of vibriosis was established in two " problem " herds in Tasmania, by the direct isolation of *Vibro fetus* from the genital tract of cows. Further evidence was obtained of the disease in other Tasmanian herds.

The most practical method of making a herd diagnosis of vibriosis under Australian conditions is being sought. As the herd bull retains infection almost indefinitely, laboratory methods of diagnosis are being investigated, including the testing of sheath-washings or semen by guinea pig inoculation, by introduction into the vagina of the unmated heifer, and by cultural means.

(*d*) *Copper Metabolism Studies on Cattle in Western Australia.*—An investigation is proceeding at the Department of Agriculture, Perth, of " falling disease " of cattle, due to copper deficiency. Several years may elapse before manifestations of the disease appear in the experimental animals.

3. Internal Parasites.

(Division of Animal Health and Production.)

The following investigations were carried out at the Veterinary Parasitology Laboratory, Yeerongpilly, Queensland.

(*a*) *Parasitic Gastro-enteritis of Cattle.*—(i) *Susceptibility of* Bos taurus *and* B. indicus *to Helminth Infestation.*—Owing to the abnormally dry conditions and difficulties of mustering, this investigation at the National Cattle Breeding Station, " Belmont ", Rockhampton, has been temporarily abandoned.

(ii) *The Degree and Persistence of* Haemonchus placei *Infestation in Calves with Pure and Mixed Infestations.*—No difference in either the degree of infestation with *H. placei* or its persistence could be detected in calves artificially infested with pure *H. placei*, or in calves with mixed infestations of *H. placei*, *Trichostrongylus axei*, *Cooperia pectinata*, *C. punctata*, *Oesophagostomum radiatum*, and *Bunostomum phlebotomum.*

(iii) *Studies on* Oesophagostomum radiatum.—Studies were commenced on the pattern of egg production, persistence of the parasite, and other aspects of host-parasite relationship. In six calves, each dosed with 20,000 larvae, the prepatent period varied between 35 and 40 days, and the maximum egg count from 740 to 1,552 eggs per gram. Egg production, according to faecal egg counts, was very irregular, and the peak of production varied from six to fifteen weeks. Thereafter the counts dropped quickly and remained at extremely low levels.

The large fluctuations in daily faecal egg counts appear to be due partly to the expulsion of immature eggs which do not float in salt diluting fluid used in egg counting. The irregular flow of ingesta from the caecum, where adult parasites may be found, into the colon, may also account for these fluctuations.

The effect on calves of large single doses, small daily doses, and of spaced doses of larvae is being studied.

(iv) *Ecology of Preparasitic Stages of Cattle Strongyles.*—Investigations have continued into the development, migration, and survival of these larvae under natural conditions.

Larvae will develop to the infective stage in the pat depending on favourable temperature without regard to other environmental factors.

Infective larvae can only migrate from pats following suitable rain. Type and duration of rainfall are important, as it is essential for the pat to become saturated before larvae can escape to the pasture. Several migrations from the same pat may occur under favourable conditions. These migrations are from larvae in the pat and not from larvae in the soil on which the pat rests.

Larvae can remain in cattle pats for up to five months in the spring, and then migrate following favourable rainfall.

Larvae will survive on pasture for a period of five-six weeks after migration from the pat.

Larvae from the field, that are active, are infective to calves irrespective of larval age.

The effect is being studied of temperature on the development of the eggs and preparasitic larval stages of the various nematodes infesting cattle.

(v) *Copper in Host-Parasite Relationship.*—Statistical analysis showed that there was no significant difference in faecal egg counts, haemoglobin, or body-weight gain between the copper-supplemented group and the control group which had a mean liver copper level of 10 p.p.m. Copper deficiency may not be a major nutritional factor affecting the host-helminth relationship in calves.

The effect of helminth infestations and of phlebotomy on blood and liver copper and various blood components was observed prior to and during the experiment, compared with that of control animals. Blood was withdrawn each day in an endeavour to duplicate the haemoglobin levels in the infested group. There was no change in plasma copper levels. Liver copper levels in the infested group fell by 86 p.p.m., while that of the phlebotomized calves fell by 21 p.p.m., and that of the controls fell by 9 p.p.m. Total serum protein levels of both groups followed a similar pattern, falling to between 4 and 5 g. per cent. and returning to the normal levels four weeks after anthelmintic treatment, or cessation of bleeding. The fall in serum protein levels in the infested group was due to a fall in serum albumin, whereas in the phlebotomy group the fall was due to a decrease in both albumin and globulin of equal magnitude. Calves infested with *B. phlebotomum* failed to absorb and store copper as well as worm-free calves.

Copper supplements are being given by subcutaneous injection of copper glycinate to weaners at the National Cattle Breeding Station, "Belmont", Rockhampton. There are no significant differences in body-weight gain or coat score between this group and an untreated control group.

(vi) *Anthelmintics*.—Studies with "Neguvon" (Bayer "L 13/59") confirmed the earlier report of high anthelmintic efficiency against the common nematodes of cattle. A dose rate of 2 g. per 100 lb. body weight is highly effective against *H. placei* and *O. radiatum*, and 5 g. per 100 lb. body weight is also highly effective against *Cooperia* spp. (including *C. oncophora*) and *B. phlebotomum*. From the small number of calves infested with *Ostertagia ostertagi* and *T. axei* it would also appear to be highly effective against these two species, especially at the higher dose rate. Neither premedication with sodium bicarbonate nor prior starvation are necessary. At the recommended dose rates the drug appears to be of very low toxicity, as no mortalities or even toxic symptoms have been observed in more than 200 calves treated in the field. Dose rates up to 12.5 g. per 100 lb. body weight have been administered without mortality, although one calf dosed at 10 g. per 100 lb. body weight succumbed. Caution is still indicated, however, as workers elsewhere have observed some toxic effects from dose rates of 5 g. per 100 lb. body weight.

Two other organic phosphorus compounds, namely, "Asuntol" and "Dow-ET-57", have shown anthelmintic effect against the common nematodes of cattle.

"Asuntol", at a dose rate of 0.25 g. per 100 lb. body weight, was highly effective against *H. placei* and *Cooperia* spp. and showed variable efficiency against *O. radiatum*. Increased efficiency against *O. radiatum* and *T. axei* was observed at higher dose rates. One calf dosed at 0.5 g. per 100 lb. body weight succumbed, and a dose rate of 0.25 g. per 100 lb. body weight would appear to be the maximum safe dose.

"Dow-ET-57", at a dose rate of 5 g. per 100 lb. body weight, was also highly effective against *H. placei* and *Cooperia* spp., and of variable efficiency against *O. radiatum*. Even at a dose rate of 10 g. per 100 lb. body weight, efficiency against the latter species was not increased. Some toxic effects were observed, although no mortalities occurred.

4. CATTLE TICK.

(Division of Animal Health and Production.)

(*a*) *Susceptibility of* Bos taurus *and* B. indicus *to Infestation*.—Studies with Shorthorn and Shorthorn-Zebu crossbreds have confirmed the earlier observations.

Observations commenced with three purebred Sahiwal bulls, one Red Sindhi bull, and two Sahiwal-Jersey crossbred bulls which had never previously been exposed to ticks. The number of engorged adult female *B. microplus* recovered from them differed greatly between individuals, but was relatively constant in the same animal on subsequent infestations.

(*b*) *Host Resistance*.—The difference in numbers of adult female ticks developing on individual animals of the *B. indicus* breeds (see foregoing) was not associated with any marked skin hypersensitivity reaction, and appeared to be due partly to the inherent individual susceptibility or resistance. The number of adult ticks recovered remained relatively constant on subsequent infestations, except in one animal which did manifest hypersensitivity. Three of these six animals developed some degree of skin hypersensitivity, as revealed by the intradermal injection of larval antigen and slight reaction following attachment of the nymphs and adults.

(*c*) *Tick Fever*.—The life history is being studied of *Babesia bigeminum* in the tick, and ultimately in cattle. Larvae become infected, and infection is transmitted either by adults from these larvae, or by their larval progeny. Larvae derived from uninfected adults and nymphs which have subsequently engorged on an infected animal have not yet produced infection in normal or splenectomized calves.

Weekly peripheral blood smears were obtained from all calves up to six months old, and monthly samples from all other stock. Only one of eleven calves sampled within seven days of birth has shown the presence of *B. bigeminum*. All have shown *Anaplasma marginale* at some time whereas only two have shown *Theileria mutans*. Among the adult cattle, 24 out of 57 animals have shown *T. mutans* at one or more samplings.

(*d*) *Parthenogenetic Development in* Haemaphysalis bispinosa.—Larval progeny of *H. bispinosa* from cattle in the field have been reared to adults on the rabbit. Of 1702 unengorged adults, only five were males. Four males were allowed to engorge on the rabbit in the presence of females. No sperms were seen in the genital tract of the females, and no functional spermatozoa in the testes of the male. Engorged adult female *H. bispinoso* reared without the presence of adult males have laid fertile eggs which have hatched to viable larvae. Some of these have been reared to engorged nymphs.

5. BIOLOGY AND CONTROL OF THE CATTLE TICK.

(Division of Entomology.)

Study has continued of acaricide resistance in the cattle tick, and the screening of new acaricides. An infra-red spectrometer gave increased range and output in acaricide analyses. Marked advances have been made in the application of pasture spelling, and ecological investigations have been extended to the most important types of cattle country in Queensland. The eradication campaign in New South Wales has continued.

(*a*) *Acaricide Resistance*.—(i) *DDT Resistance*.—Ticks with a low-order resistance to DDT have been detected on one further central Queensland property. They can still be controlled with 0.5 per cent. *pp'*-DDT. DDT resistance has not developed elsewhere.

Of six strains of cattle ticks from northern New South Wales where the eradication campaign failed, five were found to be completely DDT-susceptible, and one to have a negligible degree of DDT tolerance. Failure of the campaign was not therefore due to DDT-resistance.

(ii) *Multi-resistance*.—Cattle on a central Queensland property where ticks had become DDT-resistant were subjected to ten months' dipping in BHC and four months' dipping in dieldrin. These ticks were resistant to dieldrin, and retained their former degree of DDT resistance.

(iii) *Loss of Resistance*.—A DDT-resistant strain reverted to a low-order resistance, and a dieldrin-resistant strain reverted to almost complete susceptibility during culturing for fourteen and eight generations respectively. Spraying of infested animals with the respective acaricides resulted in one generation in a return to high resistance of the previously dieldrin-resistant strain, and a slight increase in resistance of the reverted DDT-resistant strain.

(*b*) *Factors Influencing Toxicity of Acaricides*.—(i) *Aging of Dips*.—Samples from well-used dips charged with DDT have proved more toxic than laboratory preparations of the same concentration. One freshly charged

DDT dip, in which the hardness of the water necessitated chemical softening, had a very low toxicity, but a sample from the same dip after about a year of use showed that toxicity had increased.

(ii) *Influence of Post-treatment Temperatures on Toxicity of DDT.*—Reduction in temperature favours the action of DDT on ticks. Untreated and DDT-treated ticks were exposed in the field at monthly intervals. Treated ticks always produced less progeny than untreated ticks, and failed to lay any eggs at all between April and September, whereas during most of the winter, untreated ticks produced some progeny.

(*c*) *Persistence and Fate of Acaricides on the Coats of Cattle.*—(i) *Diazinon.*—The reason for the brief persistence of diazinon on cattle hair is being studied. There was a marked correlation between persistence and coat density, and the winter coats of cattle may retain an effective deposit of diazinon for ten times the period that it persists on the short summer coats. The deposits persisted no longer on cattle shaded in stalls than on cattle grazing in the open. No evidence of evaporation from the hide was obtained, nor did chemical breakdown of diazinon occur on cattle hair at various humidites *in vitro.* Loss of diazinon by absorption into the skin is being investigated by radiotracers.

(ii) *DDT.*—It was confirmed that formulation has a pronounced effect on the size of the initial DDT deposit left on the coats of cattle, but there is no significant difference in the persistency of effective deposits. Degreasing the coats of cattle before spraying did not increase the persistency of DDT.

(*d*) *Field and Laboratory Testing of Chemicals as Acaricides.*—(i) *DDT-Diazinon Mixture.*—A mixture of 0.5 per cent. *pp′*-DDT and 0.05 per cent. diazinon in a dipping vat continued to give effective tick control. A new bioassay technique showed that there is no synergistic action between the diazinon and the DDT.

(ii) *Bayer* "21/199".—This organic phosphorus compound was tested in a dip as a wettable powder at 0.05 per cent. "21/199". It was highly toxic to cattle ticks, afforded a protective period of 4-7 days, and was stable in the dip.

(iii) *Malathion.*—An emulsifiable concentrate was more toxic to ticks than emulsions and wettable powders tested previously.

(*e*) *Pasture Spelling Experiments.*—(i) *Small-scale Controlled Experiment.*—The treatments in the pasture spelling experiment at Amberley were reversed. Heavy infestations slowly built up on cattle formerly grazed only on spelled pastures, but now running continuously on an unsubdivided paddock. These cattle, due to virtual freedom from ticks in the previous year, remain larger and heavier than the cattle formerly grazing in the heavily infested, continuously stocked paddock. Heavy infestation on the herd previously on continuous grazing dwindled under pasture spelling, but, contrary to earlier experience, some seed ticks overwintered in the paddock vacated from May to early September. Thus, although the cattle lost their infestations on each change of pasture, light to moderately heavy tick infestations built up before the next move. Negligible numbers of larvae survived the January-April period, and the heavy infestation which the cattle left behind in the pasture was reduced to a very low level three months later. None of the cattle were sprayed during the year.

(ii) *Large-scale Field Experiments.*—The three-year trial at Calliope (central Queensland) concluded in January, 1958. The scheme for 1957, in which 450 cattle were confined to one paddock during the wet season, and then divided between two spelled paddocks during the drier months, gave excellent tick control, with dippings in January, April, July (for lice), and October. At Townsville 250 cattle were dipped twice before entering a paddock which had been spelled for three months. Four months after entering this paddock the cattle had very low tick infestations. Several graziers have reported promising results from their own pasture spelling trials involving hundreds or thousands of cattle in northern and central Queensland.

(*f*) *Biology and Ecology of Cattle Tick.*—(i) *Survival of Non-parasitie Stages.*—In the study of strategic dipping and pasture spelling, observations on tick survival began near Charters Towers (rainfall 23 inches), Townsville (40 inches), and Ingham (85 inches).

In south Queensland the massed progeny of a number of ticks survive longer than those from single ticks, and survival in sclerophyll-lantana forest exceeds that in open grassland.

(ii) *Attachability of Aged Larvae.*—Larvae six and eight weeks old developed into nymphs when placed in small containers secured to shaven areas on a steer.

(iii) *Behaviour of Larvae.*—Larvae of the cattle tick and *Ixodes holocyclus* were liberated in lantana thicket and grassland. In both situations *Ixodes* larvae travelled downwards to the soil surface, whereas cattle tick larvae ascended in the thicket as high as 5 feet. *I. holocyclus* behaviour may reflect adaptation to rodent and bandicoot hosts, in contrast with that of the cattle tick, which is adapted to large hosts.

6. INVESTIGATIONS WITH DAIRY CATTLE.

(Division of Animal Health and Production.)

(*a*) *Nucleus Herds of Sindhi and Sahiwal Cattle.*—Two bulls from the Sahiwal herd at the McMaster Field Station were destroyed, and a cow from the Sindhi herd died. One young purebred Sindhi bull and two Sahiwal x Jersey cross bulls were donated to the Queensland Department of Agriculture and Stock. Two Sahiwal bulls have been sent to the Veterinary School, Brisbane University, for anatomical studies and two to the Veterinary Parasitology Laboratory, Yeerongpilly, Queensland, for observations on breed susceptibility to cattle tick infestation.

Present herd numbers at the McMaster Field Station are: Sahiwals—three males, six females; Sindhis—four males, six females.

(*b*) *Progress in the Zebu-Cross Dairy Herd.*—A further twenty Jersey heifers were obtained during the year and mated to Zebu bulls. There are at present 57 Jersey females, twelve F_1 Sindhi x Jersey heifers and eight bulls, and seventeen F_1 Sahiwal x Jersey heifers and eight bulls. The first F_1 x F_1 matings took place this autumn.

(c) *Coat Shedding Studies.*—(i) *Observations on Sindhi and Sahiwal Cattle.*—Examination of hair samples has been completed, and the data are being analysed.

(ii) *Growth and Development Studies with Calves.*—The collection of material is continuing.

(iii) *Shedding and Plane of Nutrition.*—Investigations are complete and material is being analysed. In contrast to *ad lib.* feeding, starvation appears to cause a reduction in sweat gland volume. An anticipated increase in follicle population per unit area to compensate for reduced total skin area in the starved cattle did not occur. Hair samples are being examined for medullation and for length and diameter relationships.

(*d*) *Sweat Gland Studies.*—(i) *Breed Survey.*—A survey has commenced of European dairy breeds, to obtain comparative information on gland volume and density of follicle population in summer and winter.

Through the co-operation of the New South Wales State Department of Agriculture this survey was extended to four other purebred dairy herds, in addition to the Field Station Jerseys, namely, Friesian, Ayrshire, Guernsey, and Illawarra Shorthorn.

(ii) *Variation in Sweat Gland Size, Number, and Distribution.*—Four Sahiwal and four Jersey cows have been sampled at a number of points over the body to provide this information.

7. BEEF PRODUCTION IN AUSTRALIA.

(Division of Animal Health and Production.)

The following studies (*a*), (*b*), and (*c*) are under the direction of the William McIlrath Fellow in Animal Husbandry at the McMaster Laboratory.

(*a*) *Co-ordination of Beef Cattle Investigations.*—Co-ordinated investigations conducted by the Departments of Agriculture in New South Wales, South Australia, and Tasmania are continuing. A summary of research projects undertaken by the Queensland Department of Agriculture and Stock and by the Organization was included in the report prepared by the Eighth Meeting of the Technical Sub-committee on Animal Production. The report reviews most of the beef cattle research projects in nutrition and allied fields in Australia and includes a summary of studies on comparative seasonal performance, upgrading from dairy stock, effect of time of calving, the performance of northern-bred steers when transferred to a southern environment, influence of supplementary feeding, pen and yard feeding, drought feeding, vitamin A status under different nutritional conditions, crop fattening, comparative breed performance, performance on irrigated pastures, tropical legumes and grasses for fattening, inland and coastal grazing, feeding stud cattle, use of hormones, use of phosphate supplements, progeny testing, and carcass appraisal.

(*b*) *Use of Hormones in Beef Production.*—Together with State Departments of Agriculture the value of hexoestrol and stilboestrol is being studied as growth stimulants.

(*c*) *Other Beef Cattle Investigations.*—Work is continuing on the feeding of stud cattle and the estimation of percentage of body water *in vivo.*

(*d*) *Pre-Natal Development of Skin and Hair in Cattle* (Sheep Biology Laboratory).—A histological study has been made of the development of the skin and hair follicles in 33 cattle foetuses, ranging in age from 68 to 274 days, and seven newborn calves, of various breeds. Skin samples were taken from the midlateral region of the trunk for counts of the follicle and hair population, and for skin and hair follicle measurements.

Follicle initiation extends from about the 77th day of gestation to about the 166th day. First-, later-, and last-formed follicle types are recognized and their special features and rates of development recorded. Since all the follicles are associated with sweat glands, and arrector pili muscles, no attempt was made to classify them into primary and secondary types similar to those described in sheep and other mammals. The hairs of the first-formed follicles emerge at about the 200th day and twenty days later most of the follicles have emerging hairs.

Branching of follicles was not observed as in sheep and other mammals. There is, however, the phenomenon of pairing, apparently not previously described in mammals, where two (occasionally three) follicles, rising independently from the epidermis, share a common hair canal.

Post-natal histological studies are needed of the integument, particularly of the seasonal influence on the hair cycles, for a better understanding of variations in the bovine coat associated with acclimatization.

Skin samples were collected from 22 foetuses of Zebu x Hereford and Zebu x Shorthorn strains, ranging in age from 77 to 263 days, and from ten newborn calves of Zebu x Hereford, Zebu x Shorthorn, and Zebu x Jersey strains. These will be used for comparative studies with the material from British breeds. All the foetuses have been preserved entire; they have a common sire and are from cows which were artificially inseminated at the National Cattle Breeding Station, Rockhampton.

Data have been collected for a comparative study of the pre-natal linear dimensions, body weights, and external features of the foetuses.

(*e*) *Drought Feeding of Cattle.*—(i) *All-grain Rations.*—Under pen conditions Hereford yearling steers were maintained for twenty weeks on a daily ration of 2.8 lb. whole wheat per head per day plus 1 per cent. finely ground limestone. Mean liveweight decreased from 586 to 427 lb. Similar cattle fed 1.8 lb. oaten hay, and 1.8 lb. whole wheat plus limestone per head per day decreased in weight from 584 to 464 lb. All cattle remained in good health and no deaths occurred.

(ii) *Daily versus Weekly Feeding on All-grain Rations.*—Two groups of eighteen-months-old Hereford steers with a mean liveweight of 446 lb. were fed, either daily or weekly, 3.47 lb. of whole wheat grain plus 1 per cent. ground limestone under pen conditions. Over sixteen weeks both groups maintained weight and there was no liveweight difference due to the method of feeding. At the conclusion of the experiment cattle fed weekly were livelier. This was associated with better coat shedding, earlier teeth eruption, and higher values for haematocrit, haemoglobin, red blood cell counts, and serum vitamin A. Two of ten animals in the weekly fed group had to be withdrawn because of weakness and one beast in the daily fed group died.

(iii) *Methods of Establishing Weekly Feeding of an All-grain Ration.*—Hereford yearling cattle were established on an all-grain ration (2.8 lb. whole wheat grain per head per day) in one week and changed directly to weekly feeding after a further week without untoward incidents. A second group of similar cattle treated identically for the first two weeks were gradually switched to weekly feeding over a further two weeks. There was no advantage in a gradual as compared to an abrupt transition to weekly feeding.

(*f*) *Coat Clipping Studies.*—Hereford weaners with normal winter coats made better weight gains than clipped animals when mean air temperatures were below 50° F. Skin but not rectal temperatures were lower in clipped animals. In Galloway heifers clipping reduced skin and rectal temperatures but had no effect on liveweight gain.

(*g*) *Implantation of Synthetic Oestrogens.*—Implants of 60 mg. hexoestrol in two-year-old Hereford steers in poor condition gave no increase in rate of liveweight gain over a period of four months as compared with untreated animals. Mean liveweight increased from 423 to 775 lb.

(*h*) *Adaptation to a Tropical Environment* (Rockhampton Laboratory).—(i) *Coat Type and Performance.*—Further observations confirm a relation between coat type and performance. A subjective coat score has fairly good prediction value for growth weight of weaners, for fertility of cows, and for birth weight of their calves. It seems doubtful whether the effect of coat type upon heat regulation, although it is strong, accounts for all the association between coat type and performance. Coat type may be an indicator of physiological well-being more than a cause of it.

(ii) *Analysis of Coat Characters.*—Further attempts are being made to analyse the contribution of various coat characters to overall coat quality in relation to skin temperature and growth rate. It has been difficult to obtain suitable sets of data with all concurrent information to provide definition of coat characterization. To reduce complexities, short-term growth and shedding of hair are being studied as distinct from the coat as it is found.

(iii) *Sweat Glands: Form and Function.*—Analyses are proceeding of skin thickness, sweat gland size and morphology, gland density, and surface area of glands per unit area of skin, in relation to age, season, body weight, breed and individual differences, and other characters. No significant seasonal effects have appeared. Gland size is high in Brahman and Afrikander cross, but density, though high in Brahman cross, is low in Afrikander cross. Within breeds, highly significant differences between animals are demonstrated for all skin characters. Sweating rates in the field show highly significant breed differences. These are well correlated with coat type and with growth rate, but no relation to sweat gland size has yet been found.

(iv) *Eye Lesions.*—The incidence, persistence, and development of pre-cancerous lesions of the eye in Herefords is being studied in relation to pigmentation of lids, corneoscleral junction, and eyelashes. Strong relationship exists between lesions and lid pigmentation, and the latter is highly heritable.

8. Cattle Breeding Investigations.

(Division of Animal Health and Production.)

The following investigations are in progress at the National Cattle Breeding Station, "Belmont", Queensland.

The 1957 calving was the fourth in the two main breeding experiments.

(*a*) *Crossbreeding Project: Rates of Growth.*—Observations have now been made on four drops of progeny from six crosses. Afrikander or Zebu bulls mated with Hereford or Shorthorn females give progeny which grow faster and to heavier weights than the Hereford x Shorthorn or Shorthorn x Hereford cross breds. The first F_1 mating was made in 1957 between crossbreds of breeding Afrikander x Hereford, Afrikander x Shorthorn, Zebu x Hereford, and Zebu x Shorthorn.

(*b*) *Northern-bred and Southern-bred Herefords.*—It is now fairly clear that the southern-bred strain has been inferior to the northern-bred in all aspects of production. No further matings will be made in this experiment.

(*c*) *Artificial Insemination.*—A calving of 54 per cent. was obtained in a herd inseminated in 1957 with deep frozen semen which had been collected by artificial vagina from Zebu and Shorthorn bulls. Additional bulls, including crossbreds, have been trained as semen donors. Commencing at 80 days from conception, 21 pregnant cows were slaughtered at 20-day intervals to obtain material for studies in the histology of foetal skin and hair.

(*d*) *Dentition Studies.*—Up to the age of about 27 months appreciable breed differences have been observed in size of temporary teeth and in time and nature of their eruption, but during the next year of life most of these differences have disappeared. In the animals under observation time of eruption of permanent incisor teeth has proved a poor indicator of age. No standard pattern has been observed either within or between breeds, nor is there any evidence that rate of growth of the animal is affected by earliness or lateness of eruption.

(*e*) *Conformation—Carcass Studies.*—Studies were commenced using 1954 males as the experimental animals. Special facilities for the carcass appraisal work have been provided at the Lakes Creek Abattoir of the Central Queensland Meat Export Company.

9. Sweat Glands in Cattle.

(Animal Genetics Section.)

The volume of sweat glands has been shown to be higher in breeds which are supposed to be heat tolerant. Different groups of Shorthorn, Santa Gertrudis, Zebu x Shorthorn crosses, American Brahmans, Afrikanders, and two pure Indian Zebu breeds, Sindhis and Sahiwals, were compared and their sweat gland volume follows closely their supposed heat tolerance.

Counts of resting and active follicles in cattle skin show that cattle grow two coats in the year, one in spring and one in autumn.

IX. ENTOMOLOGY.

1. General.

In Australia, as in most other countries, there are thousands of species of insects, mites, and ticks which cause serious harm to domestic plants and animals and to the products of these used by man. The investigations of such pests, with the ultimate object of reducing or preventing the damage they cause, is mainly carried out by the Division of Entomology. Collaborative work is, however, undertaken by the Division on special problems in conjunction with other laboratories. Research on insects affecting animals is done partly in co-operation with the Division of Animal Health and Production and is reported in Chapters VII and VIII. The Division cooperates with the Division of Forest Products in the study of pests of timber (see Section 14 of this Chapter, and Chapter XIV., Section 6), with the Division of Plant Industry on certain pasture problems (see Section 3 of this Chapter), and with the Division of Industrial Chemistry (see Section 16 of this Chapter).

Division of Entomology.—There have been no major changes in the research programme of the Division during the year.

Great stress continues to be placed upon the ecological approach to pest problems, with the realization that it is insufficient merely to find better ways of killing insects in order to effect their control.

An officer has recently commenced work in Queensland on the biological control of Noogoora burr. Also an officer was sent to Hawaii to collect and breed large numbers of fruit fly parasites. Regular shipments of these are being made to Sydney, and after a careful identity check to ensure that undesirable insects are excluded, they are being liberated in eastern coastal regions.

Good progress has been made in the implementation of the recommendations of the Cattle Tick Research Review Committee. An officer has been appointed to study the ecology of the cattle tick in north Queensland, and arrangements have been made to lease a small property near Ingham where pasture spelling experiments will be carried out. Additional facilities have also been provided at Yeerongpilly and Amberley so that work on cattle dips and pasture spelling can be intensified.

2. Insect Physiology and Toxicology.

(Division of Entomology.)

(*a*) *Digestion of Wool by Insects.*—Studies of the mechanism of digestion of wool by insects have continued. Recent improvements in technique have led to the purification of the protease from clothes moth and carpet beetle larvae. Studies on the effects of these preparations on wool under similar conditions to those found in the insect gut show that native wool is digested to a considerable extent by the clothes moth protease in the absence of reducing agents. Digestion *in vitro* is increased by the effect of thiols or other reducing agents, and it is thought that thiols play an important part in the digestion of wool by insects. Elemental sulphur has been demonstrated in clothes moth excreta.

(*b*) *Cuticular Proteins.*—The larval cuticle of a beetle was found to contain approximately 60 per cent. protein. Of the proteins, 56 per cent. is bound to other cuticular components, especially chitin, by covalent bonds. In addition there is: (i) a protein fraction (14 per cent.) which is not bound to other compounds and is extractable with water; (ii) two small fractions, one (2 per cent.) bound by the van der Waals force, the other (3 per cent.) by salt linkages or double covalent bonds or both; and (iii) a large fraction (25 per cent.) bound by hydrogen bonds. The various protein fractions are heterogeneous and their amino acid compositions have been studied. Important quantitative differences exist, although the various protein fractions have a similar qualitative amino acid composition.

Determinations have also been made of the inorganic constituents, chitin (37.2 per cent.), lipoid (3.2 per cent.), and polyphenol oxidase activity of the entire cuticle. The cuticle gave 0.49 per cent. ash of which half was calcium oxide. The next most abundant metal was magnesium. The ratio of calcium to magnesium in the cuticle, in the larval blood, in the wood on which the larvae were feeding, and in the frass excreted was approximately the same (5:1), which indicates that there is no preferential accumulation of calcium or magnesium and that the calcium and magnesium content of the cuticle is directly related to that of the blood.

(*c*) *Significance of Pole Cells in Flies.*—Circumstantial evidence has suggested that the pole cells of higher Diptera not only are the source of the germ cells of the gonads, but also play a role in the formation of the midgut epithelium. This has now been demonstrated experimentally by damaging the pole cells of *Drosphila* and *Lucilia* by exposure to a controlled beam of ultraviolet radiation at 2537Å. Depending upon the stage of embryological development at the time of treatment, not only are the germ cells reduced in number or lacking, but certain specialized midgut cells may suffer a similar fate. Electron micrographs of sections show that these specialized midgut cells, which have specific functions, such as the accumulation of copper, have a fine structure which distinguishes them from other midgut cells.

3. INSECTS AND VIRUSES.

(Division of Entomology.)

(*a*) *Insect Tissue Culture.*—Considerable progress has been made in the establishment of insect tissue culture as a technique for use in virus studies. Media have been improved so that it is possible to maintain some tissues in culture for many months. A polyhedral virus disease appeared spontaneously in a series of cell lines submitted to sudden changes of media, whereas similar lines kept in adequate media remained healthy.

(*b*) *Viruses of Insects.*—Exploratory work has been started on several new diseases of insects. A granulosis of caterpillars of a moth *Doratifera*, and a polyhedral disease in larvae of an Emperor gum moth have both been investigated. A very interesting disease showing a relationship with *Rickettsia melolonthae* appeared in the eucalyptus snout beetle, *Gonipterus scutellatus*. The discovery of this disease may prove important economically, for the snout bettle is still a serious pest of eucalypts in some countries despite the importation of parasites from Australia.

(*c*) *Viruses of Plants.*—The importance of the virus disease, subclover stunt, from northern New South Wales to Tasmania and South Australia, has been increasingly appreciated. The pathogen is a persistent virus and the main vector is *Aphis craccivora*. This aphid migrates southward annually in great numbers from northern New South Wales where it overwinters on burr medic and other forage plants. Infected burr medic remains a virus source for long periods and thus provides a reservoir of the virus during the winter. The majority of commercial varieties of subterranean clover, including Mt. Barker and Bacchus Marsh, are severely affected by the disease. Approximately 340 strains of subterranean clover from Australia and Europe have been examined for resistance to this virus. Eight of these strains have shown some degree of resistance. One of the resistant strains is Tallarook, which has certain useful agronomic characteristics.

Efforts have been made to determine whether the maize wallaby ear disease is caused by a virus or by the toxicity of the saliva of the vector. An extensive trial with five species of dodder failed to reveal any transmission by this means.

4. POPULATION DYNAMICS.

(Division of Entomology.)

(*a*) *Theoretical and Laboratory Studies.*—Laboratory cultures of the Australian sheep blowfly (*Lucilia cuprina*) have been held for long periods under both constant and fluctuating conditions, ranging from highly favourable to extremely adverse. It was found that the populations of flies automatically accommodated themselves to all these varied conditions, provided unfavourability was not extreme. The resultant of such automatic accommodation was the maintenance of the populations at, or fluctuating about, particular levels of numbers. These were related to the prevailing conditions, although numbers were often higher when there was heavy mortality or low fertility than under more favourable conditions. In addition, it was found that the populations remained stable in spite of a profound change in the properties of the flies, owing to natural selection in some cultures in which only minute quantities of meaty food were provided for the adults. Flies of these selected strains not only laid exceptionally large numbers of eggs when given very little meat, but also laid eggs freely when completely deprived of such food. That is to say, they become adapted to live under conditions far more adverse than those to which the flies were subjected during the period of selection.

(*b*) *Field Studies.*—(i) *Psyllid Investigations.*—With the object of supplementing the laboratory work discussed above, field studies of the population dynamics of native insects, particularly a species of *Cardiaspina* (Psyllidae) were commenced several years ago. Outbreaks of this insect consistently damage and destroy *Eucalyptus blakelyi* over a large area of the Southern Tablelands.

Recently *Cardiaspina* numbers have increased very substantially in those areas in which they had previously persisted at low levels for many generations. This increase is associated with an unusually high percentage hyperparasitism for such areas and with a very imperfect correspondence in time between the life-cycles of the hosts and parasites.

(ii) *Eucalypt Defoliating Insects.*—As a result of a preliminary survey, two species have been selected for detailed investigation. These are the sawfly *Perga affinis* and the beetle *Paropsis reticulata*. Particular attention has been paid to the sawfly which, in 1957, was responsible for severe defoliation of several important eucalypt species over thousands of square miles in western New South Wales and northern Victoria. This species has been present in even greater numbers during 1958; thus an ideal opportunity is presented for the study of its population regulation under outbreak conditions.

Considerable progress has been made in an investigation of the ecology of the sawfly, and intensive field and laboratory studies indicate that, within the total area of distribution of the species, *P. affinis* occurs as a mosaic of more or less discrete populations in which density fluctuations occur independently. Information concerning population regulation is being obtained by experimental means; for example, by the introduction of dense populations to areas of low natural density.

Comparable investigations have been made on the ecology of *Paropsis*. This species differs from *Perga* in that it does not fluctuate appreciably in numbers either in space or in time, which suggests that its mechanism of population regulation is of a rather different type.

(iii) *The Gum Leaf Skeletonizer* (Roeselia *sp.*).—A population study of the moth *Roeselia* has been initiated with the object of ascertaining the causes of its present extensive outbreaks in the river red gum forests (*Eucalyptus camaldulensis*) along the Murray River and the possibilities of preventing such outbreaks. Many trees in these valuable forests have already been defoliated completely and the outbreak shows no sign of diminishing. This investigation is being undertaken with the cooperation of the New South Wales Forestry Commission.

5. INSECT SYSTEMATICS.

(Division of Entomology.)

(*a*) *Diptera.*—Some progress has been made on a revision of the Calliphoridae or blowflies, and on certain other groups, including some parasitic flies. Revisions of the Pyrgotidae and Acroceridae have been completed.

(*b*) *Hymenoptera.*—This order includes many important parasitic wasps, particularly those of the superfamily Chalcidoidea, on which systematic studies have been in progress for several years. Special attention has been given to the hymenopterous parasites of several groups of insects on which ecological or biological control investigations are being carried out. Notable amongst these are psyllids, aphids, sawflies, and the codling moth.

(*c*) *Lepidoptera.*—A revision of the pink bollworms of cotton (Gelechiidae) and related species in Australia has been completed. Further progress has been made with a comprehensive reclassification of the Australian Tortricidae, special attention being given to the systematic position and relatives of two important pest species, the lucerne leaf roller and the light-brown apple moth.

At the request of the State and Commonwealth authorities responsible for the development of the rice industry in the Northern Territory and the north of Western Australia, a study of the taxonomy of the rice stem borers (Schoenobiinae, Pyralidae) has been undertaken. At least one species, not previously described, has been responsible for considerable losses in rice crops in this country.

(*d*) *Scarabaeoidea.*—A revision of the Rutelinae ("Christmas beetles") has been completed.

(*e*) *Acridoidea.*—Work is continuing on Volume IV. of the monograph which is being prepared by an American specialist on this group. As a result of a survey of the locusts and grasshoppers in north-western Australia, further valuable material for study has been collected.

(*f*) *Psyllidae.*—A revision of the genus *Cardiaspina*, with descriptions of new species, is being prepared in connexion with field population studies on these insects.

6. Ecology of Orchard Pests.

(Division of Entomology.)

(*a*) *Queensland Fruit Fly.*—Studies on fruit fly ecology have been in in progress at the University of Sydney (Department of Zoology) for several years, with financial support from the Rural Credits Development Fund.

Samples of fruit fly populations were obtained over several years from Cairns, Brisbane, Sydney, and east Gippsland for the purpose of comparing them in the laboratory at Sydney. The object of this was to determine how populations of *Dacus tryoni* have adapted themselves to spread into areas with such widely different temperatures. This work was completed in March, 1958. In general terms, it was found that the more southern strains at all stages were more resistant to both low and high temperatures than were strains from the more northern regions. This was found to correlate well with the greater frequency of extreme temperatures in the more southern regions. A preliminary experiment to provide information on the dispersal of adults has been carried out.

(*b*) *Codling Moth.*—The objective of this new investigation is to improve control by relating the ecology of the codling moth to that of the insects and mites with which it is associated. Present work consists of: (i) a general survey of the current situation in several fruit growing centres of New South Wales; (ii) a preliminary investigation of codling moth ecology in the Canberra area; (iii) a study of the distribution of codling moth eggs in an orchard, as a first step in the development of sampling methods on which to base a quantitative study.

7. Locusts and Grasshoppers.

(Division of Entomology.)

(*a*) *The Australian Plague Locust.*—Preparations for the Commonwealth-State trial in New South Wales of a proposed method of outbreak suppression, based upon ecological considerations, have been advanced considerably. So that a more comprehensive study could be made of the population trends in the Bogan-Macquarie outbreak area, the number of population assessment centres has been increased from 27 to 53. Assessments made in November, February, and April showed that the locust population density was well below critical levels.

The particulars of all properties lying within the outbreak area have now been recorded, and the work of surveying the soil types and vegetation dominants has continued. Under direction of the committee of management for the trial, officers of the Division have co-operated with officers of the New South Wales Department of Agriculture in arranging to get more efficient reports of locust activity within the Bogan-Macquarie outbreak area.

(*b*) *Solitary Grasshoppers.*—*Phaulacridium vittatum* and *Austroicetes pusilla* fluctuate between wider extremes and maintain higher levels of population density in the Southern Tablelands than other species of grasshopper. The occurrence of peak populations of both species is associated with relatively dry conditions between August and the time of emergence of nymphs in October or November or with overgrazing. The outstanding characteristic of *P. vittatum* is its sedentary habit. Outbreaks of this species result from multiplication and survival in many favourable places rather than the dispersal of individuals from a few outbreak centres.

Recent work has shown that young nymphs of *P. vittatum, A. pusilla,* and *Oedaleus australis* "prefer" areas of extremely low plant cover and that their population densities in pastures are inversely related to the density of plant cover. The introduction of subterranean clover into native pastures and the selective grazing of areas by sheep have resulted in a relatively high degree of permanence of sites favourable to these species.

P. vittatum feeds predominantly on rosette-forming or procumbent species of plants which are inaccessible to stock; but, under conditions of food shortage, it undertakes short-distance migrations to the nearest green vegetation, usually trees, crops, or gardens, where it does considerable damage.

(*c*) *Locusts and Grasshoppers of Northern Australia.*—During the autumn of 1958 a survey was made of locusts and grasshoppers of the Kimberley region of north-western Australia. Little is known of the insects of this region. The survey added greatly to knowledge of the distribution of the economic species which cause damage to experimental crops there. A sound knowledge of this insect fauna will become increasingly important with the development of northern Australia (see also Section 5 of this Chapter).

8. Pasture Caterpillars.

(Division of Entomology.)

As part of a study of the ecology of a series of cutworms and armyworms which attack native and sown pastures and field crops in eastern Australia, an experimental study is being made of the environmental factors inducing diapause in *Agrotis infusa.* Although the existence of a reproductive diapause has been demonstrated in a high percentage of the migrating adults sampled in the spring, the rearing of larvae in isolation or in crowds, and the various conditions of constant temperature and photoperiod so far tested, have failed to induce a comparable delay in reproductive maturation in laboratory reared adults.

Economic damage by *A. infusa* in the winter of 1957 was slight, as was expected after an excessively dry autumn. Subsequent spring migrations of adults were on a reduced scale, and populations of aestivating moths at Mount Gingera, Australian Capital Territory, were also low. Relief rains in February produced a sudden minor flush of pasture growth on the Southern Tablelands. This was followed by at least one minor outbreak of *A. infusa* larvae in early March, which is most unusual.

9. LUCERNE FLEA AND RED-LEGGED EARTH MITE.

(Division of Entomology.)

(*a*) *Insecticidal Control.—Aerial Application.*—A survey of the results of commercial aeroplane spraying operations against both pests revealed that control was either excellent or satisfactory in 91 per cent. of treatments against the lucerne flea, and in 99 per cent. of treatments against the red-legged earth mite. The unsatisfactory results appeared to be due principally to the use of equipment producing very fine droplets (mostly less than 100μ) when a high proportion of the spray was lost in drift.

(*b*) *Lucerne Flea Ecology.*—Field observations in several widely separated areas of Western Australia again revealed an extremely high mortality of lucerne fleas in populations of high initial density. The cause of this mortality was not determined. The possibility of its being a pathogen is being investigated, for an efficient means of transfer of disease organisms exists, as lucerne fleas eat the decaying bodies of dead fleas.

Population density changes similar to but less violent than those found in the field were produced in protected plots where the only known difference between plots was in the initial density of fleas. The smaller fluctuations were probably due to the maintenance of a continuous moisture supply and an almost complete pasture canopy. Laboratory and field studies revealed that there was little, if any, difference in the fertility of fleas collected from areas of different density.

10. CATTLE TICK.

(Division of Entomology.)

This work is reported in Chapter VIII., Section 5.

11. SHEEP BLOWFLIES.

(Division of Entomology.)

This work is reported in Chapter VII., Section 20.

12. INSECT PESTS OF STORED PRODUCTS.

(Division of Entomology.)

(*a*) *Grain.*—Although laboratory studies of the effects of oxygen depletion on insect pests of stored grain have continued, the main emphasis of the work has shifted to an investigation of the consequences of leakage of atmospheric oxygen into a sealed silo. In commercial practice even specially built silos are unlikely to be completely air-tight and the effects of oxygen transfer require to be determined.

Experiments are therefore in progress in which the trends of insect population density may be followed under conditions of controlled oxygen leakage. At the same time the movement of oxygen through a mass of grain has been investigated by measuring the coefficients of diffusion of oxygen through bulk wheat, maize, barley, and oats.

The Wheat Industry Research Council has made a special grant to be used for the construction of an experimental air-tight silo. This silo will have two functions: firstly, to provide facilities for a study of the performance of air-tight storage on a large scale, and secondly, to provide experience of this method of grain storage under commercial conditions.

(*b*) *Dried Fruits.*—Further assistance has been given to the dried fruits industry following the successful introduction last season of methyl bromide fumigation of fruit arriving at the packing sheds. This season the industry has agreed to the adoption of film spraying, with pyrethrum in a non-volatile carrier oil, of all packed fruit in order to protect it from infestation by the Indian meal moth, *Plodia interpunctella.*

13. BIOLOGICAL CONTROL.

(Division of Entomology.)

(*a*) *Weed Problems.* (i) *St. John's Wort.*—Colonies of chrysomelid beetles, collected from north-eastern Victoria, were liberated in the Batlow and Lobbs Hole districts of New South Wales. An inspection made late in 1957 showed that the gall-fly, *Zeuxidiplosis giardi,* was well established in the field at Myrtleford, and was spreading from the original liberation site.

(ii) *Ragwort.*—Mass breeding of *Tyria jacobaeae* was supplemented by the importation of a small consignment from England. Experiments in Gippsland have shown that the climatic conditions there are suitable for all stages of *Tyria,* and that, were it not attacked by natural enemies, this species would be capable of increasing to densities high enough to defoliate ragwort. Its principal enemies appear to be the microorganisms which affect *Tyria* at high densities and the predaceous scorpion fly, *Harpobittacus nigriceps.* Although defoliation by *Tyria* larvae did not kill the ragwort plants, the production of seed from the second crop of flowers was reduced to 12 per cent.

(iii) *Noogoora Burr.*—Following a recommendation by the Australian Agricultural Council that C.S.I.R.O. should attempt to determine the probable effectiveness of *Mecas saturnina* and *Nupserha antennata* in controlling Noogoora burr if these insects should be liberated in Australia, an officer has been appointed to investigate this problem.

Larvae of these two species were imported by the Queensland Department of Lands late in 1957, and are being held in quarantine. The factors involved in breaking the diapause in the larvae are under investigation.

(*b*) *Insect Problems.* (i) *Pests of Crucifers.*—The most important pests of crucifers are the cabbage moth (*Plutella maculipennis*), the cabbage white butterfly (*Pieris rapae*), and the cabbage aphid (*Brevicoryne brassicae*). The biological control of these has been given much attention in recent years, with considerable success in the case of *Plutella* and *Brevicoryne.*

In the past year the possibility of using insect pathogens has been considered. An extremely virulent virus disease of *Pieris* has been discovered in the field. This has been cultured in the laboratory and successful field experiments have been conducted with it. A field search has also been made for diseases of *Plutella.* The most promising so far discovered is a fungus disease.

(ii) *Green Vegetable Bug.*—*Bogosia antinorii,* a tachinid parasite of the adults and nymphs of *Nezara,* has been imported from Africa during the year with the co-operation of the Department of Agriculture, Kenya. An attempt is being made to culture this species, and small liberations have been made.

(iii) *Brown Vegetable Weevil.*—Parasites of this weevil have been imported from South America during the year. These include *Stomatomyia littoralis* and various species of *Tersilochus* (*Porizon*), all of them primary larval parasites. Liberations of *Stomatomyia littoralis* have been made. The species of *Tersilochus* are being cultured, and liberations of these have just begun.

Difficulties in maintaining the adults of *Listroderes* successfully through the summer diapause have been overcome.

(iv) *Queensland Fruit Fly.*—Early in 1958 an officer was sent to Hawaii to collect and breed large numbers of parasitic wasps (mostly species of *Opius*) for consignment to Australia and direct release in the field. Only adult parasites without host material are imported and these are checked for identity under quarantine in Sydney. They are then forwarded for liberation to a distributor travelling in the coastal belt of Queensland and New South Wales, between Cairns and Sydney.

Importations under this revised plan commenced in mid March 1958. By mid May about 21,000 parasites from Hawaii, supplemented by 20,000 reared at the Sydney insectary, had been released between Cairns and Ingham.

(v) *Wax Scales.*—A survey has been completed of the distribution of *Ceroplastes rubens* and *C. destructor* in Australia. Further information about *C. destructor* and its natural enemies has been obtained from institutions in east and south Africa. Colonies of both species have been established in insectaries at Canberra, preparatory to the introduction of parasites.

(vi) Diomus pumilio.—At the request of the Canadian Department of Agriculture, consignments of the predator *Diomus pumilio* have been sent to Canada for the control of the balsam woolly aphid.

14. Termites and other Wood-destroying Insects.

(Division of Entomology.)

(*a*) *Termite Investigations.*—(i) *Laboratory Studies.*—A survey of the natural durability to termites of ten Western Australian timbers has begun in co-operation with the Western Australian Forests Department.

Investigations on the durability of teak (*Tectona grandis*) to termite attack have shown that resistance is positively correlated with the age of the tree and extractive content.

Factors responsible for the natural resistance of black bean and tallowwood were investigated in co-operation with the School of Applied Chemistry, New South Wales University of Technology, and the Division of Forest Products.

A co-operative project with the Division of Forest Products is designed to determine the efficiency of dip-diffusion treatments for termite-proofing *Pinus radiata* timber. Results to date suggest that some of the experimental treatments are at least as effective as the available pressure treatments.

(ii) *Field Testing.*—Field tests of surface treatments which have been in progress for three years have shown that pentachlorophenol remains effective against *Nasutitermes exitiosus*, but other materials failed after two years.

Tests of soil treatments for termite control are continuing: against *N. exitiosus*, lindane, chlordane, and tetrachlorobenzene have so far given complete protection for three years; against *Coptotermes lacteus*, dieldrin and chlordane have so far given complete protection for four years, and aldrin and tetrachlorobenzene for three years. Similar tests against a termite complex in the Riverina have shown that pentachlorophenol, sodium pentachlorophenate, chlordane, and creosote have so far given complete protection for five years.

A survey of the termite hazard in the Weipa area of Cape York Peninsula was made on behalf of the Commonwealth Aluminium Corporation. The very destructive species *Mastotermes darwiniensis* is not present in the area.

(iii) *Termites in Forest Trees.*—The intensity of termite attack on living hardwood trees in Australia is not equalled in any other country. *C. acinaciformis* and *C. frenchi* together cause more damage to living trees in Australia than all other species of termites. *Porotermes adamsoni* causes much loss of timber in the alpine forest areas of Victoria and New South Wales. Studies this year have shown that one colony of *C. acinaciformis* in a living tree can attack all other living trees within a radius of 120 feet. Studies of the effects of killing such central colonies are included in the current programme.

Research has continued on the effects of large colonies of *C. frenchi* and *C. acinaciformis* on the conditions within the living tree in which they are established. Around the " nursery " area of both species the temperature was up to 40° F. higher than that of a sound tree during winter, and 22° F. or less in mid-summer.

(*b*) Lyctus *Investigations.*—Various surface treatments were tested for the prevention of *Lyctus* attack. After two years' indoor weathering chlordane, lindane, aldrin, and dieldrin are still completely effective.

15. Ant Investigations.

(Division of Entomology.)

The Division continued to co-operate with the New South Wales Department of Agriculture and local government bodies in the Argentine ant eradication campaign in Sydney.

The ant has been virtually eliminated in most of the areas treated so far, and although small infested areas are still being discovered even as far afield as Woonona on the south coast and at Wentworthville, most of these have either been treated or will be treated before next summer.

16. Insecticide Investigations.

(Division of Entomology.)

Evidence has been obtained that the resistance of houseflies capable of dehydrochlorinating DDT is increased by exposing them to sublethal concentrations of DDT during the larval stage. As this implies individual adaptation to DDT, a phenomenon not previously recorded, new techniques are being developed to differentiate between adaptive and selective effects of DDT during the larval stage.

Variations in susceptibility with aging of insects have been studied, by using water-soluble insecticides applied by a new injection method which promises to be rapid and precise.

Relationships between chemical structure and insecticidal activity have been examined in two groups of compounds, namely, volatile ketones and *N*-substituted amides of long-chain fatty acids. The former compounds were prepared at the Department of Applied Chemistry, New South Wales University of Technology, and the latter by the Division of Industrial Chemistry.

X. WILDLIFE.

1. General.

However well man's community life may be developed, wildlife in varying forms is always in close proximity and may affect primary production and other human activities. In Australia, wildlife problems range from that of the rabbit, the country's most serious pest, to the mutton bird, on which a small but valuable local industry depends. The Organization's Wildlife Survey Section scientifically studies Australia's native and introduced wild creatures with a view to their conservation where desirable or their population control where necessary. The current research of the Section is described in this Chapter.

Wildlife Survey Section.—The main research projects of the Section have continued without change. New investigations have been initiated on the dingo and the fox.

The close relation between the Section and the Antarctic Division of the Department of External Affairs has continued; and it has again been possible to second a member of the Section's staff to the Australian National Antarctic Research Expedition to carry out biological observations on Macquarie Island.

The Section has published a detailed factual report on the history and operation of the New Zealand rabbit control scheme which has excited considerable interest in Australia for some time, both in official circles and among primary producers.

2. Rabbit Investigations.

(Wildlife Survey Section.)

(*a*) *Myxomatosis.*—The Section's research projects relating to myxomatosis have now been rounded off, as it had become apparent from the field studies carried out in collaboration with Australian National University virologists that, although the disease would continue to be a factor in preventing the build-up of high rabbit populations, its activity was unlikely to be affected significantly by human intervention.

Field work on myxomatosis and its insect vectors was virtually confined to two areas, (i) New England and (ii) Colo Vale, in the coastal ranges of New South Wales. (The sequence of annual summer outbreaks in the Lake Urana study area was broken in 1957-58, owing to the prevailing drought, which resulted in an interruption of the study of developing natural resistance.) The dry season severely restricted mosquito activity in the New England region, no disease outbreak being recorded in any of the special study areas, or the district roundabout. At Colo Vale an extended low-intensity outbreak lasting from January until late in May, resulted in a substantial reduction in the local rabbit populations.

A study of the feeding habits of the local mosquitoes has been continued at Colo Vale. Controlled comparisons between human and rabbit baits have been run over 140 hr., on nineteen different evenings spread over all seasons of the year. A total of 2,155 mosquitoes were attracted to humans, and 167 to the bait rabbits, a ratio of 13:1. Of the 35 species represented in the catches, all were attracted to man, and twenty to rabbit. Fourteen of these twenty species have been shown to feed on rabbits.

Work on the European rabbit flea (*Spilopsyllus cuniculi*), which has been imported under quarantine in the hope that it would provide a myxomatosis vector that was not dependent on water for its breeding, has been disappointing. The insect has been found, both in Britain and Australia, to be the reverse of amenable to laboratory culture. Five consignments of pupae have been received from England, from which a total of 412 adults emerged. A quarter of these were successfully established on wild rabbits held in the laboratory. Some of them survived up to three months, fed continuously, and were shown to have mated; but no females succeeded in maturing eggs, despite the manipulation of temperature and humidity to provide conditions more closely approximating to the insect's natural environment. The Department of Health has now been approached for permission to breed the insects outdoors in a warren enclosure.

(*b*) *Rabbit Biology and Behaviour*.—Intensification of the study of rabbit populations has been maintained in enclosures under near-natural conditions, pilot trials having indicated that this was the best way of obtaining desired ecological data. Enclosures are currently being maintained at Canberra and on a grazing property near Albury.

The enclosure observations have revealed that rabbits have a well-defined social behaviour, and develop within their population a social hierarchy that has many important implications, e.g. on the timing and efficiency of reproduction and dispersal. Particularly during the breeding season, a rabbit population becomes subdivided and stabilized into well-defined groups each dominated by an individual buck. Mating and conception follows a pattern which reflects the hierarchical structure of the group; and reproductive success, both among males (as measured by paternity) and females (as measured by the number of young successfully dropped and weaned within the season), is higher for dominant than for subordinate individuals—overwhelmingly so when population densities become high. Thus a dominant doe in a Canberra enclosure littered nine times, producing 57 kittens, during the year; and as some of these kittens started breeding within the twelve months' period, her total offspring was 117. The corresponding figure for a low-ranking doe was a total of ten offspring successfully reared during the year, these being the product of early litters dropped when the population pressure was low.

Litters are dropped according to well-pronounced monthly rhythms, several of which may be superimposed within the population as a whole. The synchronization of sexual activity which makes these cycles obvious seems to be in part the result of the rabbits' social behaviour, and in part initiated by environmental factors such as peaks in rainfall, possibly operating via pasture growth. At Albury observations enabled the population data to be correlated with changes in nutritional value of the pasture; and evidence suggests that the animals' nutritional plane may be a factor of major importance in determining the rate of conception, particularly at the beginning of the breeding season. Reproduction does not occur under conditions of food shortage but incipient or abortive rhythms can be observed, with the males not responding to the females that appear to be in oestrus.

At the beginning of the breeding season a considerable reshuffling of the population takes place; and there is a large-scale dispersal of subdominant bucks that have been ejected from the re-forming groups. Young females also tend to be cast out, but these are usually readily absorbed by other groups.

The enclosures have demonstrated the nature and rapidity of pasture deterioration under steady rabbit grazing. Selective feeding on clover burr during the summer and on clover seedlings in the autumn leads to a rapid elimination of clovers from the pasture; and the general defoliation in spring and autumn paves the way for the invasion of broad-leaved weeds.

(*c*) *Physiology and Parasitology*.—A major advance in the strategy or technique of rabbit control is most likely to come through a better understanding of the animal's basic biology. During the year the Section's investigations in this field (which had been primarily ecological and behavioural) were augmented by physiological studies. Attention was first given to the problem of stress, now widely recognized as an important factor in the regulation of animal populations. It is now established that the physiological symptoms of stress in an animal are the same whatever the stressor agent employed, e.g. exposure to low temperature, trauma, over-exertion, and injections of adrenalin and certain other drugs. Exposure to intense cold was the stressor agent employed in the laboratory studies with wild rabbits; and it was found that the fall in blood sugar was accompanied by a rise in blood urea, showing that the rabbit was attempting to maintain blood sugar levels at the expense of protein. It was also found that the rabbit as a species was very resilient under stress, and could acquire resistance to chronic stress of lesser severity. Stress may be beneficial to a wild animal population which has to survive adverse seasonal conditions. The role of the adrenal cortex in the development of this resistance to stress is being studied. The laboratory results, which enable a reasonably accurate estimate to be made of the ability of rabbits to withstand stress in the field, are being used in an analysis of the mortality due to stress of over-population in one of the enclosure populations at Albury.

Both the Albury and Canberra enclosures are being used in an investigation of the role of endoparasites in the natural regulation of rabbit populations. So far the data obtained have been inconclusive. In the Canberra enclosure (where the rabbits are worm-free) infestation with intestinal coccidia (*Eimeria* spp.) has not revealed itself as a mortality factor under conditions of normal population density. In the Albury enclosures, the conditions likely to provide the critical information in regard to parasitic worms have not yet developed. Predation by hawks and eagles has been the most important mortality factor in the enclosures. At Canberra, approximately 60 per cent. of the kittens were lost owing to avian predation and adverse climatic conditions.

(*d*) *Rabbit Poisoning*.—Development of the investigations under this head has been interrupted owing to the unexpected interest of the enclosure results, and the need for extra help to carry out the rather laborious observations involved. As a preliminary to an assessment of the value of lures in rabbit poisoning, an attempt is being made to determine the role of the rabbit's sense of smell in the location and selection of food. Results obtained to date support the indications obtained from other enclosure experiments that scent plays a less important part in bringing rabbits to food than is generally believed and that the main value of lures or decoys often incorporated in baits is probably as an appetizer rather than a long-distance attractant. Work on poisoning is being intensified, and studies have commenced on the length of dangerous "life" of sodium fluoroacetate ("1080") baits and on bait preferences under varying seasonal conditions.

3. KANGAROO INVESTIGATIONS.

(Wildlife Survey Section.)

The investigation of the euro or hill kangaroo (*Macropus robustus*) in north-western Australia is directed towards an understanding of the nature of its competition with sheep, its ability to thrive where sheep cannot maintain themselves, an assessment of the part it has played in the deterioration of the pasture in the Pilbara district, and the need and possibility of local control.

Feeding trials suggest that the euro normally exists on a low-protein diet (and thus is probably adapted to marginal habitats, even in the semi-desert country), and that as it becomes dehydrated it eats less, so less water is required to remove nitrogenous wastes. Euros are resistant to dehydration, and can live for long periods without water. Three out of six euros confined in a waterless enclosure survived for the three months, September, October, and November. Individuals deprived of water can lose up to 25 per cent. of their body weight without distress, most of which is immediately replaced when water is made available.

The Zoology Department of the University of Western Australia is collaborating in a study of the euro's physiological adaptation to arid conditions, in connexion with which blood and urine samples have been collected for analysis and correlation with the seasonal changes in environmental conditions. The protein and water content of food plants that are seasonably available and selected by the euros will also be determined. Night observations of marked animals have shown that the euro is, in the main, a sedentary species—unlike the red kangaroo, *M. rufus.* There should therefore be little danger that a useful local reduction in numbers would be rapidly neutralized by immigration. Despite the euros' ability to go without water for long periods, the animals can be readily destroyed under favourable conditions by poisoning water points.

A method developed for aging euros by tooth succession is being applied in an analysis of population structure, and an estimation made of the birth rate and mortality rate of the young.

4. DINGO INVESTIGATIONS.

(Wildlife Survey Section.)

An investigation of the dingo, *Canis familiaris dingo*, was begun during the year. Initially, enquiries have been restricted to the north-east of New South Wales, where bonuses are paid annually on some thousands of scalps, and they have been designed to clarify the real nature and extent of the problem. The distribution of dingoes, and of dingo losses among livestock, is being analysed in relation to topography and land use, and the efficacy of present control methods—including aerial baiting—is being assessed.

5. FOX INVESTIGATIONS.

(Wildlife Survey Section.)

Work on the fox, *Vulpes vulpes*, also started during 1957-58, has been restricted so far to the regular collection of fairly large samples (mostly from the Australian Capital Territory) for the determination of food habits and the relative importance of different kinds of animal prey, the reproductive cycle, survival rate of the young, and the prevalence of infections (such as mange) which might play a part in natural control. The results will be analysed and published when they have covered a full round of the seasons. The extraordinary catholicity of the foxes' diet and important dependence on insect food, which have been revealed by studies carried out in other parts of the world, have been confirmed.

6. MAGPIE GOOSE INVESTIGATIONS.

(Wildlife Survey Section.)

The major part of the study of the magpie goose, *Anseranas semipalmata*, and its relationship to rice cultivation in the Northern Territory has been completed. Owing to their nomadic habits which are related to the changing availability of food and so to the flood cycle of the plains, these birds move from the Adelaide River to the South Alligator River each dry season and back in the wet season, the latter coinciding with that for rice growing. This movement would make their mass destruction in the Adelaide River area extremely difficult.

It has been shown that the birds have rather precise requirements of water depth and density of vegetation for breeding, and suitable areas are relatively restricted. Artificially induced increases or decreases in these factors have eliminated breeding colonies. The breeding colonies studied on the Adelaide River confine their foraging activities to fairly restricted portions of the flood-plains around the nesting areas.

The most direct and practicable approach to the goose depredation problem would appear to be through water control in the few breeding swamps in the Adelaide River Valley, carried out along lines that would make them unsuitable for nesting.

7. WILD DUCK INVESTIGATIONS.

(Wildlife Survey Section.)

The investigation into the food habits and breeding requirements of certain species of wild ducks was concluded for the erratic environment of inland New South Wales, and a comparative study was begun for an environment with a regular rainfall. This work is based in Tasmania and is being carried out in conjunction with the Fauna Board.

The movements of wild ducks have been extensively studied throughout the year and approximately 20,000 have been banded in both inland and coastal New South Wales, on the subcoastal plains of the Northern Territory, and in Tasmania. The numerous returns indicate that in 1957 there was a great exodus of wild ducks from the dry inland to waters lying in the coastal areas. The birds concentrated here until the waters dried, when they dispersed once more.

8. MUTTON BIRD INVESTIGATIONS.

(Wildlife Survey Section.)

The joint investigations with the Tasmanian Fauna Board into the economic biology of the mutton bird, or short-tailed shearwater, *Puffinus tenuirostris*, were continued with an extensive period of field work in the Flinders Island region, Tasmania, from mid November to May. A marking programme, for comparative purposes, was again carried out at Goat Island, in the Nuyts Archipelago, South Australia, at the north-westernmost fringe of the species's breeding range. During the 1957-58 season 3,118 birds were banded, bringing the aggregate total for this species to 23,439.

Three interesting recoveries of banded birds were reported during the year. The first was a fledgling bird banded at Goat Island in March, 1957, and captured twelve weeks later in the Bering Sea. The second, also recovered in the Bering Sea, was a three-year-old sexually immature bird banded at Fisher Island. The third was a seven-year-old bird caught alive by a fisherman 36 miles south of Sydney on 30th October, 1957. It had been marked as a fledgling on Chappell Island, in the Bass Strait, and its recovery so far north along the east Australian coast indicates that the foraging range of these birds during the breeding season is greater than was previously suspected. Thus far four marked birds have been picked up in the north Pacific, between Japan and Alaska, during the exodus migration from Australia.

During the last nesting season at Fisher Island additional data were collected on the age at first breeding. Evidence indicates that birds, once mated and with territory, breed annually.

9. Magpie Investigations.

(Wildlife Survey Section.)

The first phase of the population study of the magpie, *Gymnorhina tibicen,* is now complete. The most significant finding was proof that territory holding by social groups, which alone are able to breed, leads to prevention of breeding by mature individuals which lack a territory. The gonads of the latter do not develop fully. Study of the social organization of non-breeding flocks has begun, and dispersal from the Gungahlin study area of over 600 flock birds is being measured. After twelve months, most of these are within three, and a few reach ten, miles from the place of banding.

10. Bird-banding Scheme.

(Wildlife Survey Section.)

There has been a large increase in the numbers of birds banded this year. With the appointment of an experienced ornithologist as full-time secretary, the scheme is expanding rapidly.

XI. UNDERDEVELOPED REGIONS.

1. General.

Owing to the geographic distribution of climate on the Australian continent, areas of dense population are concentrated in a narrow band round the eastern and southern parts of the coast. Rural settlement has taken place in the most accessible and easily developed parts of the continent, and there remain large portions of Australia and its territories which are underdeveloped, or only very sparsely occupied, because of low rainfall, short growing season, inadequate water, poor soils, or isolation.

If these are to be protected from over-exploitation, and their full productive potential developed, it is necessary to assess and understand the scientific problems associated with such areas.

The Organization's Division of Land Research and Regional Survey is engaged in land surveys of the underdeveloped regions to study their needs and potentialities. The surveys provide a description of the lands of the region, an assessment of the possibilities of land use, and an analysis of the major problems which retard more intensive development and warrant more detailed examination. The problems are of three main kinds: those of dry-land agriculture, those of irrigated agriculture in the dry monsoon zone of the far north, and those of the pastoral areas of the inland lower-rainfall zones. To further examine the initial findings of the surveys in these fields, research centres have been established at Katherine, Kimberley, and Alice Springs, and two specialist groups are dealing with development and hydrology at headquarters.

In addition to the work of the Division of Land Research and Regional Survey in the sparsely populated and semi-arid regions of the continent, much complementary work is also being carried out by other Divisions of the Organization on the development of low producing areas in the less isolated regions.

The Division of Biochemistry and General Nutrition is investigating problems of plant and animal nutrition on the Coonalpyn Downs in South Australia (see Chapter VI., Section 11); the Division of Animal Health and Production is breeding cattle at " Belmont ", Rockhampton, Queensland (see Chapter V, Section 9); the Plant and Soils Laboratory is studying the wallum country in eastern Queensland (see Chapter III., Section 20); and the Division of Soils is making soil surveys throughout the Commonwealth (see Chapter II.). Allied work is also carried out by the Division of Plant Industry on plant and pasture ecology (see Chapter III.).

Division of Land Research and Regional Survey.—The research of the Division has continued without major modification this year. Arid zone research has been extended with the appointment of an officer to study arid zone hydrology. The three-year project on historical-geographical studies of underdeveloped regions is now reaching its final stages and reports are being prepared.

On the invitation of U.N.E.S.C.O. the Chief of the Division participated in a symposium on Climate, Vegetation, and Rational Land Utilization in the Humid Tropics held at the Ninth Pacific Science Congress at Bangkok. The second *Arid Zone Newsletter* was issued by the Chief of the Division in his capacity as arid zone research liaison officer.

Aided by a grant from the Australian Meat Board, the Division and the Northern Territory administration are collaborating in an investigation of range seeding in central Australia.

2. Regional Surveys.

(Division of Land Research and Regional Survey.)

The two regional survey units of the Division have continued operations, one on the mainland of Australia and one in the Territories of Papua and New Guinea. The first unit has been in operation in northern Australia since 1946 and has completed surveys of the following areas: Katherine-Darwin (27,000 square miles), Barkly (120,000 square miles), Townsville-Bowen (6,000 square miles), Ord-Victoria (70,000 square miles), Leichhardt-Gilbert (110,000 square miles), North Kimberley (34,000 square miles), and Georgina Poison Country (25,000 square miles). In addition the Division has made preliminary examinations of portions of the West Kimberleys suitable for irrigation development (1952) and of the Wiluna-Meekatharra area of Western Australia (1955). The New Guinea unit was established in 1953 at the request of the Department of Territories, and has completed surveys of the Buna-Kokoda area (2,500 square miles), the Wanigela-Cape Vogel area (1,600 square miles), the Gogol-Upper Ramu area (3,200 square miles), and the Goroka-Mount Hagen area (3,600 square miles).

(*a*) *Australian Mainland Survey Unit.*—(i) *Alice Springs Area.*—Field work in this area (145,000 square miles) was completed in the period June-September, 1957. The final aerial photograph interpretation has been completed, and preparation of maps of the land systems, land use groups, geomorphology, geology, soils, and vegetation has been commenced.

Although approximately half the area (mountains and spinifex plains) is not stocked, the gross returns from cattle exported from the area is more than half that of the Northern Territory as a whole. On the stocked parts the extensive system of grazing has produced an extremely uneven pattern of pasture utilization. The tendency is for small areas immediately adjacent to watering points to be heavily overgrazed. Outside this, there is a zone of good utilization, and beyond this a zone of poor or nil utilization.

The area is, and will remain, a pastoral one. There are two main possibilities for increasing production: the development of methods of utilizing and improving the vast areas of spinifex plains, and the development of methods ensuring a more even and complete utilization of the present grazed country.

In both cases it is very important to avoid over-utilization, and consequent permanent degradation, of the pastures, and accurate scientific standards of range condition assessment are necessary.

Small areas of fodder production under irrigation may become an important adjunct of the cattle industry. On most properties it would probably be economic to produce fodder to hand-feed the more valuable animals.

(ii) *Cape York Peninsula.*—In October, two officers made a preliminary examination of the agricultural possibilities of the Weipa area. This will be followed by a full-scale regional survey of the Cape York area in 1959-60.

(iii) *Historical Studies of Development in the Northern Area and Monsoonal Lands.*—This study provides information on factors which influenced the history of development. This information is useful in judging future land use potentialities from the Division's regional surveys in northern Australia.

This project is now in its final stages, field work having been completed in the northern part of the Northern Territory, the East Kimberleys, and the Barkly region. As in Queensland, the dominant factors in settlement and land utilization, other than land characteristics, were geographic ones, isolation and climate, with land tenure playing a minor role. Administrative policy is also an important factor.

(*b*) *Papua-New Guinea Survey Unit.*—From mid-June to mid-October, 1957, an area of 3,600 square miles in the Western and Eastern Highlands districts of New Guinea (Goroka-Mount Hagen Area) was investigated in the field, following preliminary interpretations of aerial photographs.

The investigating party consisted of a highly mobile team of geomorphologist, pedologist, and plant ecologist to carry out the general reconnaissance survey, and a party comprising a forest botanist and botanical collector are making detailed studies of forest types in pre-selected areas.

The far better accessibility of this area for motor transport in comparison with other parts of New Guinea, and the longer duration of the survey, made it possible to collect more detailed information from a larger area.

The area, ranging in altitude from 5,000 to 15,000 feet, is of particular interest for the study of soils and vegetation at high elevations in the humid tropics. This study is handicapped by the general youthfulness of the landforms and instability of the slopes, which impede the development of mature residual soils, and by far-reaching destruction of the natural vegetation by indigenous peoples. Geomorphologically the area is of great interest because of its volcanic, tectonic, and glacial features, its remnants of mature land forms at various levels, its unusual drainage pattern, and its alluvial terrace formations.

Of a total of 3,600 square miles, 2,050 square miles are rough mountainous country and 800 square miles very broken hilly country. Of the remaining 750 square miles, 200 square miles are strongly dissected and 150 square miles very swampy or regularly flooded. There remains an area of 500 square miles of land which could be readily developed (and is in part already so), though most of it is by no means ideal.

The area is heavily populated and most of the 320,000 natives live in mountainous or hilly areas. Some transfers of population are desirable to attain maximum stable utilization of the land resources.

3. AGRICULTURAL RESEARCH IN NORTHERN AUSTRALIA.

(Division of Land Research and Regional Survey.)

(*a*) *Katherine Research Station.*—The Katherine Research Station has two main functions: to examine the possibility of establishing agriculture in that portion of the area mapped by the Division's survey as the Tipperary Land System; and to serve as a type locality and centre for the study of dry-land agriculture in the monsoonal zone of northern Australia. The research programme has reached the stage where the most likely components of arable agriculture are evident. Studies are now being directed towards long-term land use as well as individual crops.

(i) *Crops.*—The season had a good start, followed by a prolonged period of water stress which reduced crop yields, and by late rains which damaged mature peanuts but benefited cotton and late-sown peanuts and sorghum. Promising new cotton varieties were tested.

(ii) *Soil Types.*—Encouraging results have been obtained from cropping trials on two sandy soils which differ markedly in their internal drainage characteristics.

(iii) *Land Preparation.*—Sorghum responded to greater depth of dry-land preparation than previously reported. Ripping to 16 in. was superior to ploughing to 8 in.

(iv) *Fertilizers.*—The value of rock phosphate has been shown as a substitute for superphosphate. The initial inferiority of rock phosphate is partly overcome by its superior long-term effect.

(v) *Crop Rotation.*—Although peanuts and cotton yields have not declined in nine years of monoculture, soil structure may have been affected, and long-term crop and pasture rotation investigations into this question have been commenced.

(vi) *Pests and Diseases.*—Sorghum seed stored at 14 per cent. moisture content lost viability. Jassids have become a serious factor in limiting the development of the " top crop " of cotton bolls.

(vii) *Native Pasture.*—Long-term trials are in progress on grazing management and the influence of burning and fertilizer are being studied. Cultivation and broadcast superphosphate were beneficial for introduction of buffel grass and Townsville lucerne, but pelleting of seed with superphosphate reduced establishment.

(viii) *Sown Pastures.*—In the second year of an experiment on the management of buffel grass and Townsville lucerne, the proportion of legume in mixtures increased with increasing distance between grass rows and increasing frequency of cutting. In a fertilizer trial on Townsville lucerne the species has proved an effective legume with a fairly low but definite phosphate requirement. Establishment trials with buffel grass showed dehulled seed to be inferior to normal seed under most climatic conditions.

(ix) *Annual Fodder Crops.*—Agronomic tests were continued with fodder sorghum, sudan grass, bulrush millet, cowpea, and guar. Millet outyielded all other crops in dry matter and crude protein yield.

(x) *Beef Cattle.*—In a repetition of the dry-season comparison between native pasture and buffel grass/Townsville lucerne pasture, the liveweight advantage of the sown pasture was approximately 1¾ lb./head/day. The experiment on phosphate supplementation and tick control for cattle on native pasture in the wet season was repeated in 1957-58, with similar but less marked effects.

(xi) *Nitrogen Cycle Investigations.*—Detailed sampling of the top three inches of fallowed soil at the end of winter revealed a nitrate peak at ¾-1 inch, with marked decreases to almost zero to both sides. Location of formation and possible movement of nitrate is under study. Ammonia supplied to the soil surface as ammonium sulphate oxidized slowly in summer. Nitrogen uptake by plants and leaching of soil nitrate are also being studied.

(*b*) *Kimberley Research Station.*—The Kimberley Research Station has a twofold objective. The immediate aim is to determine if irrigated agriculture can be established on the land which might be irrigated from the proposed dam on the Ord River. The long-term objective is to study irrigated agriculture in the tropical monsoonal climate of northern Australia. The search for information on potential crops has dominated the programme until recently, but, as the information has accumulated, so the more basic problems on the second objective have become evident.

(i) *Rice.*—Stem-borer damage during the past season was negligible. It is impossible to judge how much of this freedom from damage is due to seasonal conditions and how much is due to the frequent use of the insecticide endrin. Grain yields are the most satisfactory ever achieved, bulk yields of approximately 4,000 lb./acre and small plot yields of 6,000 lb./acre having been obtained.

In preliminary studies on the importance of depth of cultivation, water depth, and drainage there has been no increase in grain yield from deep ripping as against shallow ploughing; maintenance of a 6-in. depth of water instead of 3-in.; and drainage of the bays for a period during the vegetation growing stage.

Seeding of the pre-germinated seed into deep and shallow water failed to give a satisfactory plant stand in November-December. Seeding on to mud was quite successful. The seeding into water technique might be successful for the dry season crops.

As the importance of temperature and day length sensitivity in the selection of suitable varieties for dry-season rice growing in northern Australia is realized, the effect is being studied of time of planting on grain yield, spikelet sterility, and maturation period of a range of varieties. Some long-grained *indica* varieties are suitable for the dry season.

Studies on placement and time of application of nitrogen have indicated that grain yield, resistance to lodging, and time of onset of the yellowing and leaf tipping symptoms can be markedly influenced by these factors.

(ii) *Cotton.*—Fresh interest has been stimulated in this crop, as a result of the good yields obtained in the past three years. The best yield was obtained from a plot of Oklahoma Triumph which gave the equivalent of 2,934 lb. seed cotton/acre. The variety Miller was the best variety during the last season, and these high yields have been attributed to better pest control resulting from the use of endrin. In an experiment to verify this, severe foliage damage, resulting in delayed boll setting and low yield, occurred to cotton plants when endrin was used at low dilutions.

(iii) *Safflower.*—A further time-of-planting experiment has confirmed earlier work and shows that May-June plantings give higher grain yields, oil contents, and iodine numbers than July-August plantings. Mid May planting gave approximately 2,000 lb. grain/acre. Yields fell off progressively with later plantings and a late August planting gave only 50 lb. grain/acre. The poor yields of late plantings are probably the result of high-temperature induced sterility.

(iv) *Animal Production.*—In the past the emphasis in animal work has been on producing irrigated pastures and fodders for " topping off " cattle in the dry season. Those grasses and legumes capable of persisting under irrigation have all given much better production in the summer than in the cooler dry season, when production has been very low. Emphasis has now shifted to the better utilization of natural pastures by management and by supplementary feeding.

In a trial commenced in mid 1956 there has been little response to supplements of phosphate, blood and bone meal, or fodders and hay, but on rotationally grazed pastures cattle weighing approximately 550 lb. when first included in the trial at eighteen months of age have increased in the course of two years to approximately 1,000 lb. in live weight.

4. DEVELOPMENT STUDIES.

(Division of Land Research and Regional Survey.)

With the appointment of an officer to the Division who will be concerned primarily with the overall development possibilities of regions, the first area to be comprehensively examined is the Ord River area.

Following an agreement with the Western Australian Department of Agriculture, a compilation is being made of the existing technical data, and it is being examined in the light of economic factors in order to assess agricultural and settlement possibilities of the Ord River Plain. This will reveal the gaps in existing knowledge which must be filled by work at the Kimberley Research Station before more definite planning can commence. A plan is being prepared for an irrigation scheme based on rice, cotton, and sugar cane as the main cash crops.

5. CLIMATOLOGY.

(Division of Land Research and Regional Survey.)

In most of the underdeveloped regions in Australia, climatic factors are of primary importance in limiting development and productivity. The Climatology Unit has, as its main function, the study of climate-vegetation relationships to define and interpret the important elements of climate affecting plant growth and production.

The main investigations in progress are climate-vegetation studies of spinifex (*Triodia basedowii*) and mulga (*Acacia aneura*) communities near Alice Springs. The former has been in progress for over 12 months; the latter has just commenced. Each study places special emphasis on the water relationships of the community concerned, so that the proportion of the rainfall which enters the soil, and which is utilized by the plants, is measured and its influence determined. Microclimate is also studied intensively so that significant differences between macroclimate and microclimate can be given quantitative expression and the influence of microclimate on plant responses determined.

In the spinifex experiment primary results to date have been (i) that infiltration of water is markedly affected by the spinifex tussocks, penetration under the tussocks being much deeper than under adjacent bare areas, despite the fact that the ground surface under the tussocks may be several inches higher, (ii) that the depth of soil visibly wetted is observed to increase gradually but significantly over a period of months, (iii) that little growth is made by the vegetation in response to winter rains, but marked growth occurs in spring as air and soil temperatures rise, (iv) that even small falls of rain (0.25 in.) cause a measurable response in the vegetation in summer, (v) that there is little difference in macro- and microclimate except during and shortly after periods of rainy weather, (vi) that surface temperatures of exposed soil reach values of the order of 70° C. on sunny days, and (vii) that dews are rare except during or shortly after rain.

The mulga community is of special interest because it is utilized much more extensively than spinifex for cattle grazing. The primary study concerns the water balance and microenvironment of a normal community and is similar in concept and technique to the main spinifex experiment. The influence of microrelief on the distribution of grove and intergrove areas in the mulga community has been confirmed; this feature offers to depend on differences in soil water penetration. A significant proportion of the rainfall in the grove areas is intercepted by the component trees of mulga and contributes to the soil-water reservoir through stem flow. The mulga community is relatively inactive in winter, even when recharge of soil water occurs. A subsidiary experiment involves retarding surface water movement along small drainage lines in mulga with the object of increasing water penetration into the soil, and possibly reseeding exotic species into the more favourable habitat so formed. While appreciable increases in soil water can be achieved by this technique, the total amount of water may still be inadequate to enable successful reseeding to occur.

6. HYDROLOGY.

(Division of Land Research and Regional Survey.)

An officer has been appointed to undertake research in arid zone hydrology. This work involves the investigation of the water balance of selected areas, to determine the possibilities, in appropriate locations, of greater use of surface flow by water spreading or of development of shallow ground-water for local small-scale irrigation.

The first area selected for field work is in the Wiluna area of Western Australia, where investigations are being commenced in conjunction with Western Australian Government Departments.

7. ARID ZONE RESEARCH.

(Division of Land Research and Regional Survey.)

Research based at Alice Springs aims to increase the productivity of native pastures by either improved husbandry based on ecological understanding of the plant communities or by improvement of the pasture by seeding with either native or introduced species.

The former aspect is partly investigated by excluding stock, but the examination of vegetation inside and outside fenced enclosures has not yielded information on the effects of cattle grazing. This is largely due to good winter rains which produced a dense sward of ephemeral herbs which would mask any possible effects.

Reseeding experiments have been designed, and in conjunction with the Regional Survey Unit a number of sites were carefully selected for trials of methods of establishing grasses. One experiment is in progress, and in this buffel grass (*Cenchrus ciliaris*) and the native grass *Eragrostis eriopoda* were sown in a spinifex (*Triodia basedowii*) community on flat sand-plain in eight different seed-bed treatments. Winter rains induced good germination of buffel grass in treatments which produced a good seed-bed, e.g. ploughing, burning plus ploughing. Single furrows, either in burnt or unburnt spinifex, do not appear to enhance germination, but accumulated water increases soil moisture storage under the furrows two to threefold. In untreated or lightly treated plots, germination occurs, but is very poor. It is too early to assess the degree of establishment of the sown grasses.

The course of natural regeneration of the spinifex community after treatment, especially burning, is also being studied in this trial. The main effect to date is fire stimulation of germination of native species, especially the grass *Aristida browniana*, which is known to become dominant in the first few years after a fire. Ecological study is being made of large areas of spinifex accidently burnt at known times.

Another experiment was conducted to compare quadrat techniques for estimation of ground cover, including low-level aerial photography. New methods of estimating dry weight production are being developed which will allow estimates to be made without harvesting the plots themselves.

Pot tests, using oats as a test plant, have shown very high responses to nitrogen and phosphorus fertilizers on spinifex soil. Further tests are being conducted with the perennial buffel grass. The field trial therefore incorporates a fertilizer treatment as a possible aid to establishment of grasses.

For reseeding native pastures it is necessary first to introduce and test many species and a nursery is being developed for this. The majority of sowings in the nursery area to date are unsuccessful owing to germination failures. Sowings are mainly of introduced species and these will be resown where seed supplies permit. This work demonstrates the difficulty of introducing new species to the arid zone.

XII. FISHERIES AND OCEANOGRAPHY.

1. GENERAL.

The life of the sea has always been a main source of food and other essential products available to man. Being an island continent with readily accessible coastal regions, the waters surrounding Australia could prove to yield great wealth to the nation.

The Division of Fisheries and Oceanography studies the aquatic resources of Australia, including whales, the more important fish, and crustacea and shellfish, to ensure their economic use and, where necessary, their management to prevent depletion of stocks. Fundamental to this study is an examination of the environment to ascertain the variations in oceanographic conditions which affect biological production and are to a large extent responsible for fluctuations in fish occurrences.

The work of the Division is described in this Chapter.

Division of Fisheries and Oceanography.—There has been no modification in the emphasis of the work of the Division during the year.

In order to study the behaviour patterns of commercial fish, an experimental aquarium has been built on the water front at Cronulla, and the salt water supply system at the Laboratory has been modified accordingly.

A laboratory for biological and hydrological work has been established at Eden and two officers have been stationed there.

A Kelvin Hughes Fisherman's Asdic was recently installed aboard F.R.V. *Marelda.* This instrument is to be used for fish detection and particularly as an aid to the interpretation of the distribution of tuna.

The Chief of the Division, Dr. G. F. Humphrey, visited Britain, Europe, Africa, and Madagascar in August-November to recruit staff. During his absence, Dr. J. M. Thompson was Acting Chief of the Division.

The twelfth School in Marine Biology was held at the Laboratory at Cronulla in June 1958. Thirty-three students and staff were present from the Zoology and Biochemistry Departments of the Universities of Adelaide, Melbourne, New England, and Sydney.

The Royal Australian Navy provided funds for research on marine fouling, and allowed Divisional officers to accompany vessels on three occasions.

2. OPERATIONS OF RESEARCH VESSELS.

(Division of Fisheries and Oceanography.)

(*a*) *F.R.V.* Derwent Hunter.—This vessel carried out twenty cruises. Ten were concerned with the collection of data on the hydrological structure and water mass composition of the East Australian Current. Seven cruises were concerned with the measurement of carbon dioxide uptake by the ^{14}C method. Light penetration was also measured at these stations. Three cruises were concerned with tuna long-lining. The results of all tuna long-lining carried out from the Derwent Hunter, when correlated with hydrology data collected simultaneously with fishing, strongly indicate that the distribution of southern bluefin tuna is related to water mass composition.

(*b*) *F.R.V.* Gahleru.—This vessel completed 26 cruises to Queensland and Northern Territory pearling grounds. They were mostly of short duration, the longest being eighteen days.

(*c*) *F.R.V.* Marelda.—The tuna research programme was changed from a general oceanic investigation to a study of a restricted area of the south coast of New South Wales. This was done from F.R.V. *Marelda,* based at Eden. Forty-two traverses up to 24 miles offshore in an east-north-easterly direction were made and data were collected to depths of 500 m. at six stations on each traverse. More than 1,000 tuna trolled were measured and 267 were tagged.

(*d*) *F.R.V.* Jay Bee.—The 50 m. and 100 m. stations off Port Hacking were occupied once each week for regular oceanographic observations. On eight days during the year sampling from dawn to dark was arranged at the 100 m. station off Port Hacking so that measurements of carbon dioxide uptake could be made by the ^{14}C method.

3. FISHERIES BIOLOGY.

(Division of Fisheries and Oceanography.)

(*a*) *Whales.*—Material for whale research was collected from all Australian whaling stations during the winter and spring of 1957. Totals of over 800 ear plugs, 650 pairs of ovaries, and 1,200 samples of baleen were collected. Some material was collected from sperm whales taken in the vicinity of Albany, Western Australia, after the close of the humpback season.

An analysis and report have been made of the catch returns and some of the material collected. On the western coast of Australia the composition of the catch made at Carnarvon in 1957 was less favourable than in the previous two years. At Albany the catching rate has declined very considerably since 1955 and the quota was not filled in 1957. Poorer weather conditions along the western coast in 1957 may have had some effect, but the stock of humpback whales hunted on the Western coast is continuing to decline. Humpback stocks on the eastern coast of Australia and at Norfolk Island continue in sound condition.

Marking of humpback whales was continued in 1957, 101 marks being fired into whales on the western coast, 72 along the eastern coast, and three near Norfolk Island. Two marks were recovered at Carnarvon, one from a whale marked in Shark Bay two years earlier, and the other from a whale marked in the same Antarctic sector two and a half years before. One mark, fired into a whale off Moreton Island in 1955, was recovered at Tangalooma in 1957, while another whale marked near Moreton Island in 1956 was shot in Cook's Strait, New Zealand, in 1957.

(*b*) *Sea Fish.*—(i) *Barracouta* (Thyrsites atun).—Catch records from all State Fisheries Departments have been compiled and analysed. Otoliths have been examined and the results will be used for age determination studies. A grant has been obtained from the Interdepartmental Trust Fund for Fisheries Development for the construction of a vessel for barracouta research.

(ii) *Trawl Fish.*—Investigation of the Lakes Entrance fishery for flathead is complete. The stocks of tiger flathead in that area are not independent of those of the southern New South Wales coast.

(iii) *Flounder* (Rhombosolea tapirina).—The results of research on the greenback flounder (*Rhombosolea tapirina*) of Victoria and Tasmania have been prepared for publication. The yearly commercial catch in Victoria has varied from 100,000 to 150,000 lb. from 1948 to 1955 and in Tasmania from 60,000 lb. in 1947 to 18,000 lb. in 1956. The female fish reach maturity in their third year at a length of 24 cm. Spawning takes place over an extended period from April to October with a peak in August. The growth rate of this species is slow during winter (May-August) and accelerated from November to February. Four-year fish average 30 cm. in length. Two populations of subspecific rank were separated on a study of meristic differences.

(iv) *Tuna.*—Research was changed from a general oceanic investigation of southern bluefin tuna to a study of a restricted area of the south coast of New South Wales. F.R.V. *Marelda* is now used exclusively for this programme and is stationed at Eden.

All evidence indicates that the southern bluefin tuna are randomly distributed within a particular water mass, but numbers congregate where the following factors operate: vertical mixing between the Sub-Antarctic and central Tasman water masses, and shear zones apparently caused by two ocean currents moving in opposite directions. In the open ocean, regions exhibiting these features can be determined from the observation of temperature " fronts " indicated by either a sudden rise or a fall shown on a surface temperature thermograph.

Remarkably few surface schools of tuna were sighted during the tuna season in the Eden area. They did not appear south of Tathra (about 24 miles north of Eden) where a current of some magnitude, during the tuna season, moved away from the coast in an E.S.E. direction. It was in the area to the north of this current that most of the 1957-58 commercial catch of tuna was taken. Subsequently, with the rapid summer change in environment noted above, the tuna retreated south, appearing in the region of Lakes Entrance, Victoria. The commercial catch of tuna in Australian waters was 1,450 tons, the largest catch yet taken.

From October to January, 267 small (5-8 lb.) southern bluefin tuna were marked with tags consisting of a small silver dart head and a plastic tube tail, containing a tape with a number and a request to return the tag to the Division. These tags were inserted behind the second dorsal fin, and records were kept of the length and weight of each tagged fish.

(v) *School Shark* (Galeorhinus australis).—The catch statistics for school sharks caught in Australian waters were compiled and prepared in a manuscript, " The status of the school shark fishery in south-eastern Australian waters ". The recorded commercial catch of school shark for 1956 was 1,416,968 lb. in Victoria, 236,496 lb. in Tasmania, and 1,530,683 lb. in South Australia. Twenty-seven internal tags were recovered; of these four had been free since 1949, six since 1950, ten since 1951, two since 1952, two since 1953, one since 1955, and two since 1956.

(*c*) *Estuarine Fish.*—(i) *Lake Macquarie Studies.*—Most of the year has been occupied with an analysis of the Lake Macquarie data. The commercial fish catch suggests that a real drop in abundance of several species occurred in the years 1945-1953 which was the period during which allegations of depletion of the stocks in the lake were made. The drop was not general to New South Wales, and as a considerable amount of interchange of most estuarine species goes on from estuary to estuary, the state of the fish stock may have resulted from some conditions peculiar to Lake Macquarie.

The events occurred before the Division's investigations began, but the ecological studies suggest that when rainfall is heavy and prolonged the narrow entrance channel with its shallow sill into the lake prevents any rapid dispersion of the fresh water. Under such conditions in 1955 and 1956, stratification of the water occurred and was accompanied by marked diminution of the oxygen content of the saline lower strata. Rainfall records for the district show that in 1945 rainfall was heavier and more prolonged than in 1955 and 1956, and under such conditions lower strata may have undergone deoxygenation to a critical level. Such conditions would result in the death of the inactive forms of life. The algal-feeding luderick and mullet had recovered their abundance by 1951, but the predominantly carnivorous whiting, bream, and flathead had not recovered by 1956, since the plants would recover more rapidly than the animals of the benthos.

Repetition of the conditions of prolonged heavy rainfall may again influence the fish stocks in the same way.

(ii) *Western Australian Estuarine Fish.*—A study of the breeding seasons and size at maturity of eighteen estuarine-inhabiting species of fish was completed. Sufficient data to indicate the complete cycle were available for eight species only. It is assumed that because no mature or near-mature fish of the other ten species were taken in the estuaries, and in some cases because mature specimens have been taken outside the estuaries, the late gonad maturation and spawning of these species occur in sea-water.

Black bream spawn from late winter to spring, cobbler and skipjack in spring, and garfish and Perth herring over the spring and summer; flathead, sand whiting, and yellow tail are summer spawners, and yellow-eye mullet and sea mullet spawn in the winter. Fecundity ranges from 700 eggs in small cobbler to over 2,000,000 in sea mullet. The fishes examined matured in 2-4 years.

(*d*) *Freshwater Fish.*—(i) *Trout Investigations.*—The preparation of the results for publication continues. The first four papers have been published, or accepted for publication, and a general account for anglers has appeared in a Fisheries Circular.

Scale reading for the next paper in this series, the fishery of the southern region, has been carried on continuously since November, 1957, and is nearly complete.

(ii) *Fish Culture.*—The results of experimental work on farmers' dams in Tasmania and studies of the biology of tench have been prepared for publication.

(*e*) *Crustacea and Shellfish.*—(i) *Western Crayfish* (Panulirus longipes).—The fishery for crayfish at each of the island groups of the Houtman Abrolhos has been described in papers for publication. The production figures for the whole of the Western Australian crayfish catch from 1954 have been compiled, analysed, and discussed. The commercial production for 1957 was 11,830,000 lb., from 9,930,000 crayfish at a market value of £1,970,000.

(ii) *Southern Crayfish* (Jasus lalandii).—To collect phyllosoma larvae in the Port Arthur area in Tasmania three paired horizontal and vertical plankton hauls were made weekly from late October to the end of January. About seventeen specimens of the puerulus stage (0+ year) of the southern crayfish were obtained in July, 1957. Supplies of the juvenile stage were located at Hobart and Triabunna.

Crayfish have been tagged at Cape Sorell. Five different punch tag marks were used for the various size ranges. Between 1956 and 1958 more than 3,000 crayfish were marked and 66 have been recovered. Of those recovered in the Cape Sorell area, 75 per cent. showed a mean increase in length of 1 cm. for sizes as much as 3 cm. below the minimum legal size.

(iii) *Pearl Oysters* (Pinctada *spp.*).—*Growth rate.*—A cruise to Groote Eylandt in November, 1957, revealed that the 1,000 tagged oysters planted the previous year had all been removed in commercial operations. Confirmation of growth rates reduced from other data has yet to be obtained. Tests have been made with the nylon rope method of hanging shell from rafts and indications are that growth rate is maximal.

A preliminary analysis of part of several years' monthly samples of gonads from three Queensland localities has been made. The main findings are: a secular change in gonad volume has been detected in Mainland Ground material extending over three years; young oysters have a lower proportional gonad volume at spawning than older oysters; two peaks of gonad development are indicated, one in September-October and the other in February-March; there are slight differences in spawning times between different localities.

Reproduction in Pinctada margaritifera *and* P. fucata.—Regular monthly gonad samples of *P. margaritifera* and *P. fucata* were sectioned and examined, and the results prepared for publication. At first maturity, oysters are predominantly male and the rate of sex change from male to female exceeds that in the reverse direction until middle age by which time the sexes are equally common.

P. albina and *P. fucata* become sexually mature and spawn within six months of spat settlement and frequently spawn again towards the end of the first year. *P. margaritifera* is a late maturing species reaching sexual maturity in the second year.

In the pearl culture investigations, collection of gonads has continued for spawning observations, and artificial fertilizations have been carried out by using the ripest of the gonads available. S. Wada's ammonia technique has been adopted as a standard procedure.

It has been found that there is a cycle in the fertilizability of eggs, and two peaks have been found, in September and in February.

During his visit in February and March to Thursday Island, Dr. Wada obtained 98 per cent. fertilization in some experiments, but this was by using high concentrations of ammonia, and subsequent development resulted in low numbers of healthy D larvae. One such fertilization which gave 50 per cent. cleavage resulted in D larvae which lived for 34 days and reached an average size of about 125μ. These were fed on *Dunaliella*, but growth almost ceased after fifteen days.

Pearl culture investigations reached completion when culture specimens prepared twelve months ago were brought in for examination. The deposition of nacre was particularly satisfactory, and showed that half pearls would reach marketable quality in twelve months, and graft pearls in two years.

(iv) *Scallops.*—A number of 0+ scallops were measured for growth rate studies. The number of striae formed during the first year is relatively constant and the first growth ring on the scallop shell is not laid down until its second year.

Underwater observations to 50 feet were made in April, 1958, on scallop beds in Norfolk Bay. Catches made during these trials from the lower half of the D'Entrecasteaux Channel indicated that there had been a good spatfall in 1957, the adults of which will come into the fishery before the 1953 brood stocks are exhausted.

(v) *Oysters.*—*Sydney rock oysters* (Crassostrea commercialis).—During the winter of 1957 there were no serious outbreaks of winter mortality.

Pacific oysters (Crassostrea gigas).—Only a few spat have been located so far in Mallacoota, Victoria, but in Port Sorell on the northern coast of Tasmania, a bed has been discovered about seven miles from the parent stock set out by the Division in 1954. This bed contains stock of three distinct size groups, which indicates successful spatfall during the last three summers. Spat were deposited in Port Sorell, and others were carried along the coast in larval form and have settled successfully in the Mersey River, the next waterway to the west of Port Sorell.

4. TAXONOMY AND EMBRYOLOGY.

(Division of Fisheries and Oceanography.)

The reference catalogue of Australian fish has been kept up to date from current literature. A further twelve numbers of the illustrated handbook of Australian fishes have been published as monthly supplements of the *Fisheries Newsletter*. The check-list of New Guinea fishes is now being printed. This lists 1,429 species from the region and incorporates a list of the fishes taken during 1948-50 by F.R.V. *Fairwind*.

5. HYDROLOGY.

(Division of Fisheries and Oceanography.)

(*a*) *Oceanic.*—Studies on the East Australian current made from F.R.V. *Derwent Hunter* show an unexpected degree of easterly movement. The surface oxygen content of the faster moving sections of the current in general was below saturation.

Surface sampling was maintained from M.V.'s *Malaita* and *Tulagi* in the Coral Sea and the northern Tasman Sea, from T.S.M.V. *Wanganella* in the Tasman Sea between Sydney and New Zealand, and from T.S.S. *Taroona*, M.V. *Jillian Crouch*, S.S. *Century*, and S.S. *Talune* in Bass Strait.

In March-April, 1958, sampling to 1,000 m. was carried out from H.M.A.S. *Queenborough* in the region Sydney-Brisbane-Noumea-New Zealand. Fifty-nine bathythermograph and surface sampling stations and twenty stations to 1,000 m. were worked.

From H.M.A.S. *Warrego* in April, 1958, twelve vertical stations, including five to 500 m., were worked in the western Coral Sea and through the Arafura Sea to Darwin.

(*b*) *Coastal*.—Monthly coastal stations for the study of long-term trends were maintained along the New South Wales and Tasmanian coasts. Drift card releases at all coastal stations were continued and results from recaptures were published.

6. PHYSICAL OCEANOGRAPHY.

(Division of Fisheries and Oceanography.)

Sea trials of an instrument for recording temperature, chlorinity, and depth were concluded during the year. The accuracy of the instrument is temperature ±0.15° C., chlorinity $\pm 0.03\,^\circ/_{\circ\circ}$.

As part of the Division's contribution to the International Geophysical Year (I.G.Y.), monthly mean sea-levels from a number of ports on the Australian coast and adjacent islands are being collected and sent to world data centres.

The calculation of surface currents and volume transports off Sydney has been continued. By using the data from two lines of stations about 60 miles apart, the movement of water normal to the coastline, as well as parallel to it, can be calculated.

7. PRODUCTIVITY.

(Division of Fisheries and Oceanography.)

Seven cruises by F.R.V. *Derwent Hunter* made measurements of carbon dioxide uptake by the ^{14}C method with incubation both *in situ* and in a light bath on samples from 0, 25, 50, and 100 m. from three stations 25, 70, and 120 miles east of Port Hacking. A similar programme was commenced by F.R.V. *Jay Bee* at the Port Hacking onshore 50 m. and 100 m. stations in conjunction with programmes of plankton pigment concentration.

Some new equipment has been designed to improve the ^{14}C method. These include a special filtration apparatus for the samplers already designed, improvements in the sealing mechanism of the samplers, and two light baths. The ^{14}C equipment designed by this Division is now being produced commercially and has been supplied to the Institut Français d'Océanie in Noumea.

In March-April, 1958, during the joint I.G.Y. cruises of H.M.A.S. *Queenborough* and *Quickmatch*, carbon dioxide uptake measurements by the ^{14}C method, pigment concentrations, and light penetration measurements were made from the *Quickmatch* on lines of stations on the courses Brisbane-Noumea, Noumea-Auckland, and Wellington-Sydney.

8. ZOOPLANKOTOLOGY.

(Division of Fisheries and Oceanography.)

(*a*) *Bass Strait*.—In the final barracouta cruise by F.R.V. *Derwent Hunter* in Bass Strait in May, 1957, greatest abundance of zooplankton was not around the periphery of this offshore invasion as in November, 1956, but was further to the south-east.

(*b*) *Port Hacking*.—Regular collections off Port Hacking at the 100 m. station were continued until December, 1957. The spring salp swarm was even smaller than that of the previous year, and the summer peak of abundance was approached earlier in the season.

(*c*) *Oceanic*.—Zooplankton was collected on four of the cruises by F.R.V. *Derwent Hunter* concerned with a study of the East Australian Current. Results show an abundance of zooplankton on the continental slope, with a sharp decrease further offshore. When the East Australian Current is flowing strongly to the south, there is marked increase in both numbers of species and quantity of zooplankton at its western boundary with a gradual decrease towards its eastern boundary.

(*d*) *Tuna Cruises*.—Cruise DH2/57 in March-April traversed a line from Sydney to eastern Tasmania. A thermocline at 60-70 m. was present at a number of stations and zooplankton was virtually absent below this thermocline; this is unusual in the open ocean. Cruise DH12/57 examined the waters off south-east New South Wales. A large tongue of warm water containing abundant zooplankton was located between latitude 34° S. and 36° 30′ S.

9. MARINE FOULING.

(Division of Fisheries and Oceanography.)

Investigations on methods of rearing larvae of marine fouling organisms to the settling stage were continued, and particular attention was given to the problem of providing sufficient food for mass cultures of barnacle, tubeworm, mussel, and oyster larvae. A number of diatoms, algae, and flagellates have been grown in culture and tested.

The tubeworm *Hydroides norvegica* Gunnerus was raised to the settling stage in nine-ten days at 20° C. by using the green flagellate *Dunaliella terteolecta*. The larvae did not show the " searching " behaviour prior to settling that has been observed in other fouling larvae. The settling and some experimental reactions of the bryozoan larvae *Watersipora cucullata* (Busk) were observed.

Tests to measure the macrofouling settling intensity during antifouling paint trials were examined statistically. It was concluded that, provided the control plates were placed at the same station and depth, facing the same way, and 5-10 feet apart horizontally from the experimental plates, an assessment of the intensity of fouling could be made.

Observations were commenced on the behaviour of larvae when they encounter an antifouling surface. It was found that more larvae settled when the test surface was vertical.

10. PHYTOPLANKTON.

(Division of Fisheries and Oceanography.)

A method has been devised and tested for counting and differentiating phytoplankton at sea. This involves collecting 5-litre samples in a plastic sampler, centrifuging at 18,000 r.p.m., resuspending the sediment, and counting an aliquot by using autofluorescence and induced fluorescence with acridine orange.

11. BIOCHEMISTRY.

(Division of Fisheries and Oceanography.)

In January, a laboratory was equipped and an investigation commenced on the determination and function of marine pigments. Weekly collections of water have been made at the 50 and 100 m. stations off Port Hacking and other collections during cruises of the F.R.V. *Derwent Hunter* and H.M.A.S. *Quickmatch*.

XIII. FOOD.

1. GENERAL.

With the steady improvement of methods of transportation, all forms of food are being conveyed greater distances between producer and consumer; and the preservation of even the more perishable foods is assuming increasing importance. As a major food producing country situated great distances from the main food importing centres, and with a very considerable geographical problem of its own, Australia has a special interest in the preservation of food during transport.

The Organization's work on food is undertaken chiefly within the Division of Food Preservation and Transport with its main laboratories at Homebush, New South Wales, and branch laboratories at Brisbane (meat); West Gosford, New South Wales (citrus fruits); Hobart (fish, apples, and berry fruits); and at the Botany and Biochemistry Departments, University of Sydney (plant physiology and physical chemistry). The work of the Division is described in Sections 2-11 of this Chapter. Work on the manufacture of dairy products is carried out by the Dairy Research Section at Highett, Victoria (see Section 12 of this Chapter).

Work on dried vine fruits is in progress at the Commonwealth Research Station (Murray Irrigation Areas), Merbein, Victoria (see Section 13 of this Chapter).

Division of Food Preservation and Transport.—The Chief of the Division, Dr. J. R. Vickery, was invited by the British Ministry of Agriculture, Fisheries, and Food, to examine and report on proposals which have been made for the extension and development of research on meat in Britain. He spent approximately five months in Britain (January-June, 1958) on this task. During his absence, Mr. E. W. Hicks was Acting Chief of the Division.

One of the new co-operative projects initiated during the year was a three-year investigation of levels of fruit spray residues and their removal, begun jointly with the New South Wales Department of Agriculture and financed by a special Commonwealth grant with assistance from other bodies.

Dairy Research Section.—The research programmes of the Section have continued in the pattern of previous years, major activities including: development of food products from milk, investigation of flavour chemistry of dairy products, packaging of cheese, mechanizing cheese manufacture, and better understanding of milk proteins.

The Section suffered a great loss by the death of Dr. K. Kumetat.

The cheese curd fusing machine on which the Organization has filed patent applications both in Australia and overseas was completed and put through successful trials, and could be the first effective attempt to completely mechanize cheese manufacture.

2. Physics.

(Division of Food Preservation and Transport.)

(*a*) *Rail Transport*.—Further work on the fan car built by the Queensland Railways has been carried out in collaboration with the Division of Horticulture, Queensland Department of Agriculture and Stock. Its performance has been studied when loaded completely with warm produce, and information has been obtained to assist in planning the most satisfactory stowage methods for the mixed loads which are commonly carried in it.

(*b*) *Canning Processes*.—Work has continued actively on several aspects of the theory of canning processes and practical techniques for evaluating the adequacy of particular processes from the point of view of sterilization of packs.

Studies of the effect of the variation with temperature of the thermal properties of food packs on the form of heating and cooling curves have been completed.

Improvements in experimental techniques have permitted satisfactory completion of work on the errors introduced into measurements of temperatures in cans during processing by conduction of heat along the thermocouples used for measuring the temperatures. The requirements for accurate measurements during the early stages of cooling are much more stringent than those for precise determination of the properties of heating curves which are required for process calculations.

The estimation of the contribution of the cooling phase to the sterilizing value of a process is more difficult than that of the heating phase. The conventional methods for evaluating the cooling phase are not as soundly based as is desirable. A detailed study of the cooling of packs which heat by conduction is in progress. Under certain circumstances, there may be some movement of product within the cans during the early stages of cooling although the heating is purely by conduction, at least during that part of the heating phase in which there is significant destruction of bacterial spores.

Progress has been made with an assessment of the uncertainties in estimates of the sterilizing value of a process arising from various causes but more work is needed.

Contributions have been made to the mathematical theory of process evaluation.

(*c*) *Water Relations*.—Measurements on the water relations of foodstuffs have been continued. Because of interest in published data on the amount of water which remains unfrozen in foodstuffs containing proteins, samples of dried beef prepared by freeze drying are being equilibrated with ice at 0° F. to determine the equilibrium water content.

(*d*) *Colour Measurement*.—A study of the colorimetric data obtained on tomato purées has shown that it may be possible to grade the product according to colour by measuring the reflectance at three selected wavelengths.

(*e*) *Freeze Drying*.—Equipment for drying concentrated sugar solutions has been constructed and tested, for routine drying of products for non-enzymatic browning studies.

3. Food Chemistry.

(Division of Food Preservation and Transport.)

(*a*) *Volatile Products of Apples*.—Volatile products are related to flavour and to the storage disorder superficial scald. Tests for hydrocarbons besides ethylene were continued. The absence of higher olefines was confirmed by gas chromatography.

(*b*) *Control of Superficial Scald*.—A number of volatile hydrocarbons were found to reduce scald, and the influence of unsaturation is being investigated. Control by oil wraps may be related to this effect and a number of mineral oils are being tested. Secondary amines related to diphenylamine reduced scald, but not as effectively as diphenylamine itself.

(*c*) *Natural Coating of Apples*.—The natural coating affects the metabolism of the stored fruit through its control of gas exchange. Particular attention is being given to the oil fraction which increases during storage. Apples treated with diphenylamine (which controls superficial scald) were found to develop oil with less conjugated unsaturation. The insoluble cutin fraction was found to yield carbohydrates and proteins as well as ether-soluble acids on saponification.

(*d*) *Lipid Metabolism of Avocados*.—Studies of the chemical changes in avocados during development and storage were completed. A fraction associated with the phospholipids was examined chromatographically. A number of new lipids, which appear to be hydroxy esters, were isolated, and work on their structure is continuing.

(*e*) *Studies on Fatty Acids*.—A kinetic study is being made of the isomerization of unsaturated fatty acids with potassium *tert*.-butoxide, which has application in lipid analysis.

(*f*) *Anaerobic Decomposition of Ascorbic Acid*.—This reaction is the one concerned in the destruction of vitamin C in stored canned foods. Further data on the yield of furfural at various temperatures and pH levels were obtained.

(*g*) *Protein Chemistry.*—Problems in food preservation which involve changes in proteins include toughness or " stringiness " in frozen fish, " drip " in frozen beef, and inactivation of enzymes in canning. An attempt is being made to define these changes and distinguish between " aggregation " and " conformation " or " denaturation " changes. The influence of urea, heat, and freezing has been studied. Although urea causes marked " conformation " and " disaggregation " changes in a number of proteins it has been shown that aggregation reactions following denaturation may occur in the presence of urea under the right conditions of temperature, concentration, and pH. Experiments have been started with the aim of defining the environment of protein molecules during the freezing of solutions or gels by measuring the salt concentration, pH, and protein concentration during the freezing process under controlled conditions.

The effects are being investigated of freezing on the actomyosin system of fish muscle. It has been shown that dissociation of dissolved actomyosin is promoted by increasing the salt concentration and lowering the temperature, pH, and protein concentration. The changes are accelerated by freezing and thawing; however, if the temperature is such that dissociation is minimal, then freezing and thawing tend to produce aggregation of the protein. The two proteins, actin and myosin, which combine to form actomyosin, are also being studied separately. Some progress has been made in the preparation and purification of fish actin, and the isolation of fish myosin has recently been undertaken.

Another problem being considered is the mode of clotting of milk by rennin, a process involved in cheese making. Only the caseins are altered, and an attempt is being made to determine which casein is the primary target of attack. The aggregation of the caseins is also being studied. The kappa-casein fraction has been isolated and purified, and the contention confirmed of von Hippel and Waugh that it is the primary site of rennin action.

(*h*) *Polarography.*—A review of polarographic methods with special reference to trace analysis has been published. Contributions to polarographic methodology and the polarography of amino acid metal complexes are in course of publication. Polarographic methods are being developed for the determination of sulphydryl groups, involved in protein aggregation and denaturation.

(*i*) *Chemistry of Non-enzymic Browning.*—Work has continued on the use of freeze-dried fruit purées for the study of non-enzymic browning and the identification of the cationic and anionic compounds formed during browning. Overall quantitative values had previously been obtained for the amino acids before browning and for the amino acids and 1-(*N*-amino acid)-1-deoxyfructoses after browning. It has now been shown that the Moore and Stein method for the determination of amino acids, by means of elution chromatography on columns of a buffered cation-exchange resin, can also be used to determine amino acid-deoxyfructoses. This method has been used to obtain quantitative values for these compounds in freeze-dried apricots before and after storage for twelve months at 25° C. and 70 per cent. R.H. Progress has been made with the determination of individual organic acids by elution chromatography.

The reducing value of the reaction product has been used to study the reaction between glycine and glucose in syrups with a pH and water content similar to those of the freeze-dried fruit. Initial rates, expressed as first order constants, have been determined at different temperatures with and without bisulphite and organic acids. The general course of the reaction in the presence and absence of bisulphites is also being studied by chemical and spectrophotometric methods.

A number of reaction products from aldoses and bisulphites and from glucose, bisulphites, and amines have been obtained in crystalline form. A high-voltage zone electrophoresis apparatus has been built and is being used to study products of the glycine-glucose reaction not previously identified.

4. MICROBIOLOGY.

(Division of Food Preservation and Transport.)

(*a*) *Water Relations of Microorganisms.*—Physiological studies of the relation of the internal solute concentration of bacterial cells to that of the growth medium have been continued with halophilic and non-halophilic organisms. Osmotic adjustment of cells of *Vibrio metchnikovi* on transfer to a more concentrated medium has now been obtained in the absence of a nitrogen source. The changes in solute and water content involved are being studied further.

The internal concentrations of sodium and potassium in cells of *Staphylococcus aureus* increased as the water activity of the growth medium was reduced by the addition of sodium chloride. Potassium was always predominant.

The ability of some strains of Gram-positive bacteria to grow in media of high salt concentration appeared to be associated with accumulation of very high internal levels of potassium when grown in low-salt medium. The importance of potassium in osmotic regulation is being investigated.

Various washing treatments on the retention of internal solutes have revealed major differences in the permeability properties of Gram-positive and Gram-negative bacteria.

Studies on the water requirements for growth of *Clostridium botulinium* types A and B have been completed. The lower limit for growth and toxin production was at a water activity of 0.94. Vegetative inocula grew at a water activity slightly lower than that required for spore germination.

(*b*) *Heat Resistance of Spores.*—Research on heat resistance of spores equilibrated to low moisture contents led to the hypothesis that heat resistance is associated with the maintenance of relatively dry internal conditions. Permeability studies with heavy water using an improved method of purification of the water samples showed that the heavy water mixes freely with all or nearly all (perhaps 99 per cent.) of the water contained in the spores. Differences in the volume of the spores and the volume of total water suggest that the spores are unlikely to maintain a large volume of the contents in a relatively dry state. These experiments are being continued.

Vapour pressure isotherms of intact and disrupted spores are in progress to determine whether the contents show properties different from those of intact cells.

(*c*) *Drying of Microorganisms.*—Previous work on the death of microorganisms during storage in the dry state has been extended to include more organisms and several gas atmospheres. The results of further large factorial experiments have been analysed statistically and found to support the theory that death in the dry state may result from a reaction between carbonyl compounds and amino groups on cellular proteins. A paper on the mechanism of death was read at a recent symposium on freezing and drying in London. Some determinations of carbonyl compounds in the freeze-dried material have been commenced in order to provide more direct chemical evidence on the mechanism.

Steady loss of viability during storage in the dried state is usual with cells but dried spores of three species have been stored at water activities from 0 to 1.00 for over two years, and negligible loss of viability has occurred except at zero water activity. Experiments have shown no effect of amino acids, sugars, and carbonyl compounds on the viability of spores stored in the dried state.

Studies of the physical conditions during the drying process have been commenced with an apparatus designed in collaboration with the Physics Section. Factors such as degree of precooling, rate and temperature of drying, nature and concentration of solutes in suspending fluids, and the final water content of dried suspensions have been studied and shown to affect the mortality during the drying process. Drying from the frozen state appears not to be necessary, as has often been supposed, for optimal recovery of sensitive organisms, and in the presence of certain solutes mortality of some organisms was least when they were dried at temperatures above 0° C.

5. MEAT.

(Division of Food Preservation and Transport.)

(*a*) *Nature of "Drip" Fluid from Thawed-out Frozen Meat.*—Earlier work on the total solids, ash, and pigment composition of drip and its behaviour in the ultracentrifuge has been extended by more detailed analyses including chloride and albumen content. As these constituents are presumed to be predominantly extracellular in origin estimates of the relative contributions of intracellular and extracellular solids to the drip can be obtained. These indicate that with small samples of muscles the soluble constituents of drip are predominantly of intracellular origin while with larger sections of meat the extracellular solids contribute increasingly to the drip composition.

Current studies on the difference in composition between drip and the fluid which exudes from unfrozen muscle and the electrophoretic patterns of these fluids, as well as those of fluids expressed under pressure from thawed and from unfrozen samples, are expected to throw further light on the origin of drip and on the changes in muscle constituents brought about by freezing.

(*b*) *Tenderizing Processes.*—The changes in nucleotides (with ultimate production of hypoxanthine) which take place during aging of meat and which have been shown to parallel those of eating quality have been extensively studied as to their temperature and pH dependence. With frozen meat and hypoxanthine production is negligible during frozen storage and takes place during the freezing and thawing stages. Studies are under way to determine whether this reaction, like several others, can proceed with appreciable speed at temperatures just below the freezing point.

(*c*) *Storage Investigations.*—Further data have been obtained on the effects of different rates of freezing, with and without prechilling, on the appearance, shrinkage, drip, and eating quality of beef.

(*d*) *Thermal Properties of Beef Carcasses.*—Extensive studies are under way on the temperature distribution within beef carcasses during freezing and the relation of this to the temperature and rate of flow of the air in blast freezers. This work will provide checks on suggested formulae for rates of freezing and also supply appropriate design data.

(*e*) *Bacteriological Studies.*—Fundamental studies have continued on the influence of temperature and carbon dioxide content of the gaseous environment on the growth rate of typical pseudomonads capable of growth at chiller temperatures. Metabolic experiments with high carbon dioxide atmospheres have shown no inhibition of oxidative activities comparable with the inhibition of growth.

Some recently isolated Gram-positive psychrophiles have been tentatively assigned to the family Micrococcaceae. Fundamental studies on their physiology will be undertaken.

The efficacy of a number of available bactericides has been studied for sterilizing the hides of beasts by dipping before slaughter. The effects of concentration and time of immersion on the reduction in bacterial load on hides have been established but economic considerations suggest that such methods are at present not likely to replace existing practices.

(*f*) *Ozone Studies.*—Difficulties in analytical determination of ozone at low concentrations as outlined in the previous report have been investigated and the procedure has been standardized against physical measurements involving microdeterminations of density differences. With the use of the new procedure, rates of reaction of ozone with muscle tissue are now being studied at lower concentrations than was previously possible.

(*g*) *Freezer-burn Investigations.*—Earlier work on the factors responsible for freezer-burn has been extended by studies of the rates of moisture loss and development of burn from offals which have undergone varying degrees of surface desiccation during freezing.

6. FISH.

(Division of Food Preservation and Transport.)

(*a*) *Fundamental Investigations.*—Work has continued on some aspects of denaturation of proteins in frozen fish muscle and on the methods for extraction of actomyosin in salt solutions. Investigations have been commenced on the post-mortem changes in prawn flesh and their effects on glycogen depletion and ultimate pH. A tank suitable for holding live prawns has been constructed to enable the work to be carried out on freshly killed prawns.

(*b*) *Applied Investigations.*—Studies have been made on the susceptibility of canned prawn flesh to grey and black discoloration. Conditions of post-mortem holding of the prawns and various methods of precooking prior to canning have been examined.

Spoilage in miscellaneous fish products has been investigated and bacteriological examinations of water used in fish and prawn processing have been carried out.

7. EGG INVESTIGATIONS.

(Division of Food Preservation and Transport.)

(*a*) *Disorders in Eggs.*—A pink discoloration in the white and abnormalities in the yolk of eggs are caused by hens eating plants of the order *Malvale*. These disorders have been produced by feeding to hens malvalic and sterculic acids, two related fatty acids isolated from these plants. The onset of this "pink-white" effect and the changes involved in the eggs are being examined.

(*b*) *Hatchability.*—In view of the disruptive effect that sterculic acid has on eggs, an examination in collaboration with the New South Wales Department of Agriculture was made of the effect of this acid on hatchability of eggs.

(*c*) *"Pink Rot" Disorder in Western Australian Eggs.*—Examination of eggs showing this disorder has been made and it now seems certain that the disorder is not caused by microbial attack on the eggs. It is probable, too, that it is not due to the ingestion of feedstuffs containing malvalic and sterculic acids.

8. FRESH FRUIT AND VEGETABLE STORAGE.

(Division of Food Preservation and Transport.)

(*a*) *Plant Physiology and Biochemistry.*—Investigations on the physiology of sugar cane with the Colonial Sugar Refining Company have been concerned with the mechanism in cane tissue which accumulates sucrose in such high concentration.

Mitochondria, the centres of much cellular respiratory and synthetic activity, have been investigated further; the relation of the respiratory enzymes to mitochondrial structure and ion content is being investigated. Mitochondria extracted rapidly from cells accumulating ions show increased ionic content during accumulation.

Work on the biophysical properties of the giant cells of *Chara australis* was resumed, with the use of radioactive isotope techniques to investigate the fluxes of chloride and sodium ions. In collaboration with Dr. J. Dainty, Head of the Biophysics Department, University of Edinburgh, studies were made of the permeability of *Chara* cells to water. Both diffusional permeability (using D_2O as a tracer for H_2O) and osmotic permeability (by transcellular osmosis) are being measured.

Analyses on the peas grown in the plytotron at California Institute of Technology showed that temperature of growth had a marked effect on composition, especially the sugar content of the seed. Work on peas reported earlier has been concluded temporarily with determinations of phytic acid which may be involved in the hardening of peas and which showed a pronounced increase after the rise in starch.

Investigations on sucrose synthesis were continued; a study of the properties of enzymically synthesized sucrose was completed. Uridine diphosphoglucose (UDPG) pyrophosphorylase which forms UDPG, the precursor of sucrose, was purified from pea seed extracts and its presence in a number of other plant tissues established. The properties of this enzyme and the reaction which it catalyses were studied, and also properties of a phosphatase from peas, which hydrolyses both glucose 6-phosphate and glucose 1-phosphate and which is potentially important in the control of carbohydrate metabolism.

Studies on the mechanism of inhibition of glycolysis by oxygen (the Pasteur effect) in a pea seed extract were continued. The rôle of triose phosphate dehydrogenase as the locus of the oxygen effect was confirmed; the mechanism was related to the sulphydryl-group level of the protein.

The hypothesis that oxygen may inhibit photosynthesis by oxidation of the sulphydryl groups of glyceraldehyde phosphate dehydrogenase was tested in collaboration with Professor J. S. Turner, Botany School, University of Melbourne. Extracts prepared from isolated spinach leaf chloroplasts contained glyceraldehyde phosphate dehydrogenase which was inhibited by oxygen.

Methods for estimation of phosphorylated compounds which play a major rôle in the control of respiration and synthetic processes have been improved. Work on changes during the ripening of avocados and tomatoes was completed for publication.

The physiology of fruit development and maturation was investigated in Granny Smith apples from Griffith and Orange and in Jonathans from Orange, for the second season. This work, in co-operation with the Division of Plant Industry, aims at a more physiological approach to judging the best maturity for harvesting.

Tasmanian Jonathan apples from thinned and unthinned branches on the same tree were used to define more clearly the physiological differences between large- and small-celled fruits.

Fruit development, maturation, and ripening were investigated for the second season on a crop of Williams pears at the Bathurst Experiment Farm from blossom to harvest to establish physiological, morphological, and anatomical changes.

(*b*) *Applied Research.*—(i) *Gas* (*or Controlled Atmosphere*) *Storage of Apples.*—The effects of varying levels of carbon dioxide and oxygen on disorders and fruit quality in the variety Granny Smith were investigated. In 1957 the apples were unusually susceptible to superficial scald, the most serious storage disorder of this important variety, and oxygen tensions of less than 2 per cent. were required to reduce it; there was no marked effect of carbon dioxide on scald.

Though various gas storage atmospheres improved fruit quality after long storage, the best effect was obtained when both several per cent. of carbon dioxide and low levels of oxygen were present.

(ii) *Control of Superficial Scald on Apples.*—Large-scale experiments have confirmed the complete effectiveness of diphenylamine as an inhibitor of scald, provided that adequate amounts are applied, either by dipping or by enclosing the apples in diphenylamine impregnated wraps. Work on pre-harvest spray treatment is continuing. If human toxicity studies by the United States Department of Agriculture result in diphenylamine for fruit being cleared by public health authorities, it will be recommended to the industry. The roles of ventilation and fruit volatiles in scald development are still under investigation.

(iii) *Packaging.*—The Division is still associated with development by the paper industry of corrugated fibreboard boxes for fresh fruit. The quarter-bushel cherry box and the half-bushel tomato box have proved quite satisfactory containers but further structural improvements are necessary in the bushel apple box.

Sealed polythene case liners which almost eliminate shrinkage in storage and offer possibilities of "in-case controlled atmosphere storage" have been again tested with several varieties of apples and pears. At present their use with suitable precautions is recommended only for two varieties of pears. The storage life of grapes can be usefully extended by these liners in conjunction with "in-package" sulphur dioxide treatment.

(iv) *Mould Wastage in Pears.*—A dip treatment with sodium orthophenylphenate has controlled blue mould in stored pears but the possible skin injury has not yet been overcome.

(v) *Tree Nutrition and Fruit Quality in Apples.*—In conjunction with the Chemists' Branch, New South Wales Department of Agriculture, a study has begun of the relations between the nutritional status of the tree and the yield and eating and keeping qualities of Delicious apples.

(vi) *Spray Residue Removal.*—The problems of excess residues of toxic spray materials on fruit is of increasing importance and complexity, and could threaten export of apples and pears.

(vii) *Control of Wastage in Citrus Fruit.*—Protection against mould in oranges stored for longer than three-four weeks has been achieved by following the sodium orthophenylphenate "rinsed" treatment with a skin coating of 0.5 per cent. sodium orthophenylphenate in wax emulsion. This combines the effective mould treatment with the advantages of waxing.

A new method of applying wax coatings, "foam waxing", appears to be economical, simple, and advantageous to established packing houses.

(viii) *Queensland Fruit Fly* (Co-operative Investigations with the Entomological Branch, New South Wales Department of Agriculture).—When 63,394 fruit fly larvae in oranges were fumigated with ethylene dibromide, no survivors occurred, provided that not less than 2 p.p.m. of ethylene dibromide entered the juice. This work, carried out in small 10 cu. ft. chambers, is being repeated in the large chamber at Gosford.

9. CANNING AND FRUIT PRODUCTS.

(Division of Food Preservation and Transport.)

(*a*) *Vegetable Canning.*—Green peas, the major vegetable canning crop, have continued to be the subject of investigations directed towards raising quality standards.

The maturometer, an instrument designed in the Division and now widely used in the canning industry for the assessment and prediction of maturity in peas, has been redesigned to incorporate some modifications which improve its performance and increase its usefulness. Errors due to variable friction in the sliding bearings on the guide posts have been eliminated by the use of four ring springs. In addition, the ring springs permit the range of the instrument to be readily extended so that texture measurements may be made on blanched and canned peas as well as on raw peas. Maturometers fitted with ring springs were tested under experimental and commercial conditions during the pea seasons in New South Wales and Tasmania and found to be entirely satisfactory in performance. A maturometer was motorized and with the aid of automatic recording equipment a study was made of the force-penetration curve.

Further studies on specific gravity grading indicated that this operation efficiently separated maturity grades provided that gases were completely removed from the peas during blanching. Measurements of the volume of gas liberated during blanching provided additional evidence that the major changes occurred during the first 40 seconds of blanching. It appears that blanching times in use at present for most size grades of peas could be substantially shortened.

Tasting tests on canned peas which had received a series of different blanching treatments failed to reveal any differences in acceptability. However, the low can vacua for unblanched peas and peas blanched for very short periods confirmed the need to eliminate gases from peas before canning.

Variety trials on tomatoes for processing were continued in the 1958 season with four varieties grown at Richmond, New South Wales. As in the three previous trials, the variety Urbana was outstanding in yield and was satisfactory in chemical composition and organoleptic properties.

Interest by ricegrowers and canners in the canning of rice prompted investigations which led to the development of procedures for the preparation of acceptable packs of canned white rice, fried rice, and creamed rice.

(*b*) *Fruit Canning*.—Maturation studies on J. H. Hale freestone peaches were continued for a third season at Bathurst, New South Wales. Drought conditions which persisted until a few days before harvesting markedly affected the growth rate of the fruit. In previous seasons the growth rate curve showed a single maximum shortly before the normal harvest date, but in the present season two district maxima were observed. The second maximum appeared soon after the drought conditions were relieved by rain and irrigation. Chemical studies on fresh and canned peaches and tasting tests on the canned fruit have demonstrated some trends associated with maturity. None of these trends, however, appears to be sufficiently consistent to provide a reliable objective index of maturity in freestone peaches.

Further investigations on orange juice concentrate, canned and pasteurized in a spin cooker, have confirmed its instability in colour and flavour at ordinary storage temperatures, even with the addition of 100 p.p.m. of sulphur dioxide. The pasteurized product, however, retains very satisfactory quality for at least one year when stored at 32° F.

An experiment which has been designed to provide information on the storage of berries canned in syrups of different concentrations is still in progress. Another experiment has the main object of studying the use of pectin in syrups for canned berry fruits.

A study of a problem associated with the use of wooden punnets has already yielded some useful information on methods of treatment. These punnets are used for the transport of berries from the farm to the processing plant.

(*c*) *Chemistry of Processed Foods*.—Substantial progress has been made towards the identification of the four anthocyanin pigments of blackcurrants. One has been shown to be identical with chrysanthemin (cyanidin-3-monoglucoside) and another is probably a delphinidin monoglucoside. A careful re-examination of the other two pigments revealed that rhamnose as well as glucose was split off by acid hydrolysis. Cyanidin 3-rhamnoglucoside was synthesized by lithium aluminium hydride reduction of rutin, and proved to be identical with one of the blackcurrant pigments. The remaining pigment is a delphinidin rhamnoglucoside.

Determination of chlorophyll content of run-of-the-pod samples from a crop of peas (Canners' No. 75 variety) during maturation showed a decrease with increasing maturity according to the relation:—

$$\text{Chlorophyll content (mg/100 g. fresh wt.)} = -0.0217 \text{ M.I.} + 11.616,$$

where M.I. is the Maturometer Index over the range 150-300. The ratio of chlorophyll A to chlorophyll B was 62 : 38 and was independent of maturity in the range studied. There were marked differences in chlorophyll content between varieties and between growing districts when crops were compared at the same maturity.

(*d*) *Container Investigations*.—Experimental work has been completed in the project on the evaluation of 1 lb. per base box electrolytic tinplate, which has been conducted in co-operation with the Commonwealth Canmakers' Association. The large volume of accumulated data is being analysed. Tests made on eleven canned foods indicate that, while electrolytic tinplate cans may be expected to be satisfactory for a wide range of products, they may be unsatisfactory for some specific foods.

On behalf of the Navy and Air Force, the canning of water in tinplate and plastic containers has been investigated in order to provide a stable and palatable water ration for lifeboats and Carley floats.

10. Frozen Fruits and Vegetables.

(Division of Food Preservation and Transport.)

(*a*) *Berry Fruits*.—It has been demonstrated that the quality of strawberries, but not raspberries, is improved by holding them in syrup before freezing. This observation requires confirmation.

Frozen strawberries and raspberries, in syrup, have been stored at 0° F., at 14° F., and with the temperature fluctuating between 0° F. and 14° F. The results confirm that for retention of quality over twelve months, a temperature of 0° F. is essential. The relationship between temperature and storage behaviour of strawberries, packed in dry sugar, is being investigated.

Projects in progress will provide information on the effect on frozen berry fruit quality of vacuum syruping and rapid immersion freezing. In addition the effect of temperature on quality retention in frozen raspberry pulp intended for jam making is being investigated.

(*b*) *Freestone Peaches*.—Freestone peaches, of the same variety but grown in different districts, showed marked differences in quality when frozen. Data have been obtained on the correlation of tannin content and polyphenolase activity of peaches with browning of the frozen product. The influence of thawing rate on acceptability is being evaluated.

(*c*) *Peas*.—A comprehensive experiment with the variety Canners' No. 75 was designed to provide information on the yields of different size grades at several maturities and harvest dates, and on the influence of maturity, date of harvest, size grade, and quality grade on the acceptability of the frozen product. The results indicate that peas with an alcohol insoluble solids (A.I.S.) content of 9-12 per cent. give the highest quality product, but that a range of 9-14 per cent. is satisfactory for commercial use. For any given A.I.S. value large peas were preferred to small peas. Date of harvest showed no independent influence on product quality.

(*d*) *Sweet Corn*.—Studies on the relationship between maturity and the quality of frozen sweet corn are continuing. Laboratory methods for assessing the quality of frozen sweet corn have been examined and the per cent. alcohol-insoluble solids of the frozen product was found to be a reliable guide to the maturity of the raw material.

(*e*) *Stringless Beans*.—The sloughing of the epidermis of frozen stringless beans is being investigated in conjunction with an experiment to determine the effect of maturity on quality.

(*f*) *Cauliflower*.—The discoloration of frozen cauliflower during storage is being studied.

11. DEHYDRATED FOODS.

(Division of Food Preservation and Transport.)

(*a*) *Vegetables.*—A third and final year's trial on pea crops maturing at Hawkesbury Agricultural College has defined the range of maturometer readings which can be considered satisfactory for peas intended for dehydration.

Several workers have shown that if small slits are cut in the skins of peas before dehydration the drying is facilitated and reconstitution improved. A satisfactory means of applying this idea in practice is needed. A mechanical slitting device has been designed and will be tested this season.

Conventionally dehydrated green beans remain somewhat shrivelled on cooking. Freezing of beans after blanching and before drying produced samples which were more like the fresh product.

For the third year, quality tests were done on potato varieties grown by the New South Wales Department of Agriculture. Varieties occupy similar rankings from year to year.

Efforts to produce an " instant " rice have shown that if rice is fully precooked and dried at 170° F. for 2 hr., it will reconstitute to produce a satisfactory, ready-to-eat article merely by the addition of hot water and 10 min. standing.

(*b*) *Fruit.*—Sulphur dioxide is normally incorporated into dried tree fruits to preserve colour and flavour. Existing industrial procedures of sulphuring often result in concentrations of the preservative differing widely from allowable specifications. Following a study of basic factors affecting sulphur dioxide absorption and retention, equipment is ready to apply this information on a pilot scale.

The Division's technique for lye dipping of prunes prior to drying is being used in some areas where trouble has been experienced.

A preliminary study of the efficiency of a typical apple-drying kiln has given useful data which may be used to improve the present methods of drying or " evaporating " apples.

At the request of the Tasmanian Apple Evaporators' Association, an attempt has been made to develop a simple factory method of measuring the moisture content of dried apples. It appears that a method may be available to give a rough but useful estimate of moisture content in the apples before packing.

(*c*) *Dehydrated Mutton.*—Drying rates of minced, precooked mutton have been studied in a through-draught drier. The effects of air speed, temperature, humidity, fat content, and rate of loading have been examined.

A storage trial with freeze-dried minced mutton, raw and cooked, has been carried out. The results indicate that the minced cooked meat will prove to be very acceptable.

Certain deteriorative changes take place in dried meat during storage in the absence of oxygen and are generally referred to as " browning ". Two attempts were made to limit these changes, the first with sulphur dioxide and the second by lowering the moisture content with in-can desiccants. The latter experiment is still in progress, but the former has been completed and promising results have been obtained.

(*d*) *Dehydrated Beef.*—The storage studies on air-dried beef mince have been completed. The process, normally used for the dehydration of mutton, will apply quite well to beef.

The collaborative experiment with the New Zealand Department of Scientific and Industrial Research on vacuum-dried raw beef chunks has been completed. Precooking and a lower temperature of drying may result in a much improved product.

12. DAIRY PRODUCTS.

(Dairy Research Section.)

(*a*) *Cheese.*—Complete mechanization of cheese manufacture has now been achieved, and the process has been successfully demonstrated to the industry. Negotiations are proceeding for manufacture of a commercial-scale plant. Experiments with the prototype have influenced the design of the commercial plant, which will allow a wider range of treatments to be applied to the curd.

Studies have been made on cheese milk in which the production by bacteria of lactic acid takes place relatively slowly. The strains of bacteria which are inhibited by such milk in laboratory activity tests have been found susceptible to the action of agglutinins in raw milk. Extracts from colostrum, found to contain agglutinins and peroxidase, gave similar inhibitory effects to the raw milk.

To improve the presentation of exported cheese, officers of the Section co-operated with the Cheese Manufacturers' Federation and the Victorian Department of Agriculture in preparing two experimental shipments of rindless cheese in " Cryovac " and " Paraform ". The first reports are encouraging.

A project has been initiated on the physico-chemical factors responsible for the shrinkage of curd in cheese manufacture.

(*b*) *Flavour Chemistry.*—In studies of fishy flavour in butterfat, the use of gas chromatography has permitted the isolation of a number of carbonyl compounds. The compounds contributing to the flavour are being identified through their 2,4-dinitrophenylhydrazones followed by synthesis of the corresponding aldehydes.

The separation of flavouring compounds by gas chromatography is complicated by water and by solvent impurities. Ways of minimizing such effects are being studied. The usefulness of the apparatus was increased by the addition of a new recorder and by improvements in temperature control.

Completion of two years' observations on the susceptibility of Melbourne market milk to oxidized flavour has confirmed that copper-induced oxidation shows a maximum in midsummer and a minimum in midwinter, while light-induced oxidation was at a maximum in winter months and a minimum in December.

(*c*) *Microstructure of Dairy Products.*—Examination of the microstructure of cheese curd by fluorescence microscopy was extended to sections expanded on the surface of distilled water. Fluorescence microscopy has also been applied to observation of the progress of lipolysis in rancid milk.

Anoptral phase-contrast equipment used in microstructural studies has aided investigation of the effects of denaturing reagents on casein and of the differences in roller and spray-dried milk powders after reconstitution.

(*d*) *Vitamin Fortification.*—Assistance has been given in the commercial application of the work already done on the fortification of skim milk powder with vitamin A. Laboratory investigations have included a study of the stability of vitamin A in the milk when reconstituted.

(*e*) *Modified Milk Products.*—Work on new food forms for milk solids has continued with attempts to make use of the special milk powders in biscuit manufacture. Preliminary experiments have been made on the value of whey proteins as egg substitutes.

Further studies were made of the viscosity changes which take place during concentration of skim milk and during treatment with alkali or with calcium-sequestering agents.

(*f*) *Butter.*—Large-scale experiments in Victoria, and in Queensland in collaboration with the Queensland Butter Marketing Board, have shown that lowering of the cold-storage temperatures of butter from the present level of 12° F. did not improve the keeping quality. The causes of the greater deterioration which takes place on the surface of stored butter, and the extent to which this surface layer affects the quality of prints prepared from the butter, are being studied.

(*g*) *Flavour of Recombined Milk.*—In studies on the effect of various additives or treatments on the flavour of recombined milk, some increase in acceptability was found on increasing the non-fat solids, dried buttermilk and some other substances such as glyceryl monostearate, sucrose, and sodium citrate being added.

(*h*) *Sodium Hypochlorite in Milk.*—Sodium hypochlorite, commonly used as a sterilant on dairy farms, could gain access to milk by accident or design. Experiments showed that hypochlorite could be detected by smell (the usual method of grading milk at factories) after two hours when added at a level of 80 p.p.m. The effect of such additions on the methylene blue test was studied, and a field survey of the incidence of hypochlorite in milk supplies was commenced.

(*i*) *Miscellaneous.*—The development of commercial interest in flavoured milk drinks has been fostered by giving technical assistance, particularly in the preparation of homogenized chocolate-flavoured milk.

At the request of the Casein Manufacturers' Association a survey is being undertaken of the quality and manufacturing problems of this industry.

The thiobarbituric acid test is used as a measure of fat deterioration. Investigations are being made to determine the particular compound in oxidized fat which is responsible for the reaction.

In connexion with a project for the development of a simple field test for solids-not-fat content of milk, comparisons were made between lactometric and gravimetric determinations. Results of the two methods differed rather more than has been reported elsewhere.

13. Dried Vine Fruits.

(Commonwealth Research Station, Merbein.)

The Station again tested the commercial dipping oils available to sultana growers and found as in previous years that there was not much variation between them in performance, although they varied notably in stability. The proportion of dried sultana cuticle extracted with the solvent chloroform does not vary greatly from year to year.

Dipping detached sultana skins in alkaline emulsions increased permeability to water fourfold over permeability of untreated skins at 30° C. The ratio fell with higher temperatures and at 70° C. there was little difference in permeability between treated and untreated skins.

Skin condition of fresh grapes left on the vines very late in the season was still very good following the unusually warm autumn of 1958, compared with market deterioration early in other, unfavourable seasons. Skin condition was determined with the maturometer devised by the Division of Food Preservation and Transport for examination of canning peas.

Further investigations on the use of solar radiation for drying vine fruits were made at the Station by an officer of the Division of Industrial Chemistry, and facilities were also provided for investigations by the Department of Primary Industry into dehydration of fruit on the rack.

XIV. FOREST PRODUCTS.

1. General.

The optimum national advantage from Australia's timber resources can only be achieved with the aid of fundamental data on the properties, potentialities, and correct methods of treatment of our timbers.

The Organization's Division of Forest Products, with its laboratory in Melbourne, was formed to carry out investigations on Australian forest products and to give direct assistance to all concerned in the utilization of forest resources.

The Division's research is directed toward more effective use of these resources, by reducing waste in forest, mill, and factory; by reducing losses from decay and insect attack; and by improving the quality of timber produced in the growing forest by the study of the relationship between silvicultural treatment and timber properties. The work of the Division is reported in this chapter. Some work on timber pests is undertaken by the Division of Entomology (see Chapter IX., Section 14).

Division of Forest Products.—The research programmes of the Division have continued without major change from the pattern established in previous years; nor have there been any changes in senior or administrative staff.

The Chief, Mr. S. A. Clarke, visited England at the request of D.S.I.R. to advise on problems related to the pulping of plantation thinnings. He also represented Australia at the fourth F.A.O. Wood Technology Conference at Madrid.

A highlight of the year was the first conference in Australia of representatives of Forest Products Research Laboratories in the British Commonwealth, and this was possible because of the venue of the Seventh British Commonwealth Forestry Conference in Australia and New Zealand (see Chapter I., Section 11).

The Sixteenth Pulp and Paper Co-operative Research Conference was held in the Division in November, 1957, and was attended by research personnel from the Australian paper companies and New Zealand Forest Products Limited, as well as officers of the Division.

The cooperative programme with the plywood industry functioned smoothly during the year. Plant demonstrations of peeling techniques and methods of control were held in all the States and New Guinea.

The pole investigations have also continued in co-operation with pole-using authorities and forest services. Additional cash contributions for this work amounting to over £5,000 and material to the value of £600 were received.

Representatives of industry have also been trained in the Division. Assistance was given to some 3,000 visitors and 12,500 inquiries have been answered.

The help and co-operation of the State Forest Services, the Commonwealth Forestry and Timber Bureau, the New Guinea Department of Forests, the paper companies, the Australian Plywood Board, the pole using authorities, and all branches of the timber and allied industries are gratefully acknowledged.

2. Wood and Fibre Structure.

(Division of Forest Products.)

(*a*) *Anatomical Investigations.*—The examination of the anatomy of timbers of the South-West Pacific area has continued, particular attention being paid to members of the Burseraceae, Sapindaceae, and Sapotaceae. Generic descriptions for the Burseraceae have been completed and the data assembled for publication. Much of the work on the generic description of the Sapindaceae has also been completed. Assistance has been given to the Forests Department and the C.S.I.R.O. resources survey team in New Guinea in the botanical classification of many species. The detailed study of the anatomy of eucalypt timbers has continued.

(*b*) *Identification and Identification Methods.*—Some 590 timber specimens were identified during the year for Government Departments and the trade. The revision of the card sorting key for timbers of New Guinea and neighbouring islands has been completed and sets have been distributed. Of particular interest has been the identification of fourteen specimens of *Nothofagus* out of twenty specimens taken from drift logs on the east coast of Macquarie Island by the 1957 A.N.A.R.E. party stationed there. The structure of some of these specimens is similar to that of species of the genus growing in South America and it is suspected that the drift logs have come from South America. The extractives from New Zealand red and silver beech (*Nothofagus fusca* and *N. menziesii*) have been examined chromatographically. There are several distinctly different compounds in the extracts from the two species and there is no difficulty in identifying them from their extracts. Samples of other species of the genus are being examined.

(*c*) *The Microscopy of Cold Soda Pulps.*—Because of the increased application of the cold soda process in Australia the structural changes which take place in the wood and wood fibre during the process have been investigated. Attention has been directed particularly to the location of failure and to the nature of the bonding surfaces available during sheet formation. Cold alkali soaking causes considerable swelling of the fibre walls but this swelling is restrained externally by the heavily lignified outer regions. On mechanical disintegration of the alkali treated chips, failure occurs between the outer and middle layers of the secondary wall, which thus exposes the middle layer as the bonding surface when the fibres are felted together. This layer is relatively low in lignin content and consists mainly of cellulosic and non-cellulosic polysaccharides so that the development of strong bonds between these surfaces can be understood. The cold soda process is more applicable to hardwoods because the lignin content of the middle layer of the secondary wall is less than in softwoods.

(*d*) *Surface Growth in Plant Cells.*—The multi-net mechanism of surface growth demonstrated for oat coleoptiles is apparently also operative during the phase of surface growth in differentiating wood fibres. It has been observed that the cellulose microfibrils are oriented transversely to the longitudinal cell axis on the inner surface of the cell wall, but are dispersed from this orientation on the outer surface where the final microfibril orientation at maturity reflects the extent and polarity of the growth which has taken place. In both differentiating fibres and oat coleoptile parenchyma bundles of longitudinally oriented microfibrils have been observed at the cell corners. In coleoptile parenchyma these were formerly regarded as secondary thickening, but their location on the outer surface of the cell wall indicates that, in fact, they are localized elaborations of the primary wall. The idea has been advanced that these ridges arise because, at the cell corners, the plasmodesmata are absent, so that the process of microfibril deposition and disorientation proceeds unimpeded by the plasmodesmata in the pit fields. At the conclusion of the phase of extension growth, development of a secondary wall, which has been detected by both optical and electron microscopy, takes place. This consists of a helically wound system of microfibrils.

(*e*) *Assessment of Wood Quality.*—The examination of wood, taken from pith to bark of thirteen standing elite trees of *Pinus elliottii* by the Queensland Forestry Department, has been completed. Preliminary results show a high degree of correlation (1 per cent. level) between fibre length and micellar angle and between basic density and percentage late wood; correlations (5 per cent. level) have also been observed between micellar angle and longitudinal shrinkage, and between basic density and longitudinal shrinkage. The incidence of compression wood has been checked in successive growth rings. In co-operation with the Forestry and Timber Bureau, Canberra, similar work is in hand for 30 elite trees of *Pinus radiata*. The specimens were taken from bark to bark through the centre of each tree.

(*f*) *Wood and Bark Extractives.*—In 1954 work in this Division showed that certain tannin extracts contained leucoanthocyanins. It was suggested that these could be the precursors of tannins, and of certain heartwood polyphenols of some species. Recent results have amplified and confirmed this suggestion. The type of linkages encountered in complex leucoanthocyanins has been shown to be different from those of catechin polymers, and further that the linkages in different tannins are different.

In order to gain further information on the origin and precursors of heartwood polyphenols, the distribution of shikimic acid in eucalypt leaves of different sizes was determined. It was found to be present in greatest amounts in spring growth. Evidence indicates that polyphenols are synthenized *in situ* in the cambium, sapwood, and heartwood of eucalypts and are not translocated.

Klinki pine frequently contains pink areas which turn green in the presence of certain varnishes or other materials containing hydrochloric acid. The colour reactions are specific to this species and are due to degraded lignin.

3. WOOD CHEMISTRY.

(Division of Forest Products.)

(*a*) *Reaction Wood.*—The ultraviolet absorption spectrum of tension wood lignin from immature trees has been found to resemble that of lignin from the outermost zone of heartwood from mature trees of the same species. The difference spectra (alkali - neutral) which characterize the phenolic portions of the lignins did not differ. The evidence indicates that the pecularities of tension wood lignin are traceable to the non-phenolic portion.

(*b*) *Lignification in* Eucalyptus regnans.—Sections from the zone of differentiation in the growing tree have been dissolved, and the ultraviolet absorption spectrum of the lignin determined. Variations in the spectra at different distances from the cambium have indicated a decreasing proportion of conjugated units in the lignin as the process of lignification proceeds.

(*c*) *Acid Hydrolysis of Cellulose.*—The hydrolysis of eucalypt cellulose, in the fibrous form and in solution, has been investigated. The degree of polymerization was determined from viscosity measurements in cupriethylenediamine. Rate constants, energies of activation, and entropies of activation have been evaluated for various stages of the reaction. From the influence of particle size and acid concentration, in addition to time and temperature, conclusions have been drawn as to the structures and mechanisms involved in fibre hydrolysis, among them that the concept of a sharp distinction between accessible and crystalline regions is inadmissible, and that diffusion and hydrogen bonding may influence the course of the reaction.

(*d*) *Thermal Degradation of Cellulose.*—The initial stages of cellulose degradation are of practical interest in the drying and utilization of paper, wood, cotton, and rayon, in the weathering and aging of cellulosic materials, and in the study of the combustion of trees, grass, dry wood, and cigarette papers. Solid-phase infra-red spectroscopy offers a convenient means of characterizing the complex residues resulting from the thermal degradation of cellulose and of exploring the chemical changes which, at temperatures below or on the threshold of charring, commonly lead to darkening and loss in strength in cellulose fibres, papers, and yarns and in wood. At 250° C., the oxidative nature of the initial stages of thermal degradation in air is indicated by the development of carbonyl groups. The reaction quickly penetrates the crystalline regions as shown by complete destruction of the carbohydrate spectrum. A relative stable structure, in which carboxyl groups have largely replaced aldehyde groups, appears to develop after *c.* 12 hr. The decline in hydrocarbon and hydroxyl groups, the changes in composition and colour, and the distribution of carbonyl bands are consistent with the development of non-aromatic but somewhat unsaturated, cyclic structures.

(*e*) *Correlation of Constituents with Papermaking Properties.*—Pulps have been prepared from *E. regnans* chlorite holocellulose by treatment with 0.2, 1.0, 3.0, 5.0, 7.0, 10.0, and 20.0 per cent. sodium hydroxide at 20° C. Handsheets could not be formed from the untreated holocellulose nor from the freed fibres after extraction with 0.2 per cent. sodium hydroxide. However, extraction with the higher concentration gave satisfactory handsheets with maximum strength properties after the treatment with 3.0 and 5.0 per cent. alkali. The strength properties declined rapidly as increasing strengths of alkali were used. Although the strength properties did not alter greatly over the range of 1-5 per cent. alkali extraction, the pulp yields decreased from 60 to 51 per cent. About 60 per cent. of this could be attributed to loss of xylan. The lignin contents of all alkali extracted samples remained the same.

(*f*) *Pulping of New Guinea Timbers.*—Mechanical and semi-chemical pulps have been prepared from klinki pine (*Araucaria klinkii*) and several low-density light-coloured hardwoods. Good-quality pulps were obtained from *Excoecaria agollocha* but the mechanical pulps from klinki pine were inferior to similar grades of pulp from radiata pine and spruce.

(*g*) *Factors Influencing Paper Properties.* — The influence of alkali treatment on the beating response and interfibre bonding capacity of wood and cotton fibres has been studied. By including virtually pentosan-free materials in these experiments and by following the transition from the cellulose I crystal form to cellulose II by means of infra-red spectroscopy, it was possible to separate the contributions to beating and paper strength made by non-cellulosic polysaccharides, by other alkali-soluble material, and by changes within the fibre such as residual swelling and swelling capacity. On the basis of these results a reappraisal of the " hemicellulose theory " of paper strength has been attempted.

(*h*) *Measurement of Drainage Resistance of Pulp and its Implications.*—An instrument has been built for automatically recording drainage rate data, from which drainage resistance can be evaluated. This apparatus is used in conjunction with a standard handsheet machine. The influence af various factors, such as stock concentration, type of pulp, and degree of beating, on the drainage resistance, which is derived by applying the theory of filtration to an incompressible porous medium, has been determined. Attention has been given to the possibility of predicting drainage behaviour and drying requirements from furnish and freeness data. This necessitates the compilation in the laboratory of data relating these variables to both drainage resistance and equilibrium water retention, under suction, but, by arranging this information in the form of suitable diagrams, indices related to practical requirements can be obtained from the traditional freeness measurements.

(*i*) *Flow of Pulp Suspensions in Relation to Beating and Stock Pumping.*—Pine, eucalypt, and *Araucaria* pulps have been used in a study of the rheological behaviour of fibre suspensions at various stages of beating in the Lampen mill and Valley beater. The flow has been investigated in a rotational viscometer, and the water retention under suction and fibre length has been measured on the same samples. Increases in hydration tend to increase the effective viscosity, while fibre shortening tends to decrease it, so that the response to beating is determined by which of these factors predominates. For eucalypt pulps the fibre shortening predominates, and for pine pulp the two effects almost balance.

4. TIMBER PHYSICS.

(Division of Forest Products.)

(*a*) *Sorption Studies.*—The sorption isotherms and heats of wetting of the hemicelluloses from *Eucalyptus regnans* were determined. Their sorptive capacities were found to be considerably greater than those of any other constituents and their heats of wetting were also correspondingly greater. From the sorption measurements of all the constituents, after allowing for probable changes during isolation, it was concluded that to a first approximation the sorption of water by dry wood may be considered as the sum of the amounts sorbed by its constituents. The swelling of the isolated lignin during sorption of water vapour was also studied. It was found to be reproducible after several cycles, and it was estimated that, for methanol and Klason lignins over a range from 0.6 to 0.9 relative vapour pressure, a maximum of 60 and 80 per cent. respectively of the water being adsorbed entered the lignin structure. Outside this range of vapour pressure, the fraction of adsorbed water contributing to the swelling appeared to be smaller.

During the year attention has been given to the kinetics of sorption of water by wood. The final equilibrium moisture content of wood exposed to a given relative vapour pressure during adsorption has been found to be greater than a larger vapour pressure step is involved. Under the same conditions, the rate of approach to equilibrium is considerably greater when a large vapour pressure step is used, being greatest when the step starts from the dry state. The size of the step is not the only factor determining this rate, however, since, for approximately equal increments in vapour pressure, the rate of approach to equilibrium decreases sharply as higher vapour pressures are approached. Neither diffusion nor thermal effects are considered adequate to account for the observations and further studies are being made.

(*b*) *Rheological Studies.*—Automatic equipment has been developed to study the effects of stress on rate of creep, of strain on rate of relaxation, and of mechanical conditioning on creep. The work has included tests at stresses and strains between 50 and 85 per cent. of the ultimate values. In creep, the time to failure at stresses much above 85 per cent. is very short, and tests proved impracticable without modifying the equipment.

Increase in creep rate with stress is small up to about 65 per cent. of the ultimate value, but at stresses between 65 and 70 per cent. of ultimate strength, the rate begins to increase many times more rapidly with increase in stress. This is true even for loads of one hour or less in duration, but is much more marked when the loading is continued for longer periods. It is the smallness of the effect of stress on creep rate at stresses below 65 per cent. of the ultimate strength that has made this effect so difficult to detect previously, as the natural variability of wood tended to mask it at the lower stresses previously used.

Mechanical conditioning has been found to occur quite markedly in wood at stresses above 65 per cent. of the ultimate value, but it is not yet clear to what extent it occurs at lower stresses. Mechanical conditioning reduces both the recoverable and irrecoverable parts of creep but neither part is entirely eliminated. However, as the recovery rate is much slower than the creep rate it is possible that a substantial increase in recovery may take place in very much longer times than those of the experiment and so reduce the estimate of remaining irrecoverable creep. Cyclic relaxation tests have shown that relaxation curves are closely reproducible.

(*c*) *Electrical Resistance Moisture Meters.*—An analysis of the results of species correction tests carried out on brush box (*Tristania conferta*) has revealed an unusually large negative correction which increases at high moisture contents, and a high variability. These factors place an upper limit of approximately 16 per cent. moisture content on determinations obtained with a commercial electrical resistance moisture meter if a useful accuracy is to be obtained.

A detailed study of the problems of sampling arising in the determination of species corrections for resistance type moisture meters has commenced with an investigation of the moisture meter readings for radiata pine with respect to ring age, height in tree, tree age, and locality of growth.

(*d*) *Instrumentation.*—Equipment designed and constructed includes: a ten-channel static and dynamic strain gauging unit, automatic testing machines for the determination of the rheological properties of wood, and a small special-purpose analogue computor.

5. TIMBER MECHANICS.

(Division of Forest Products.)

(*a*) *Species Testing.*—The testing of dry material from a number of timbers from the eastern States, including 90 from Queensland, is nearing completion.

A table of properties for a large number of timbers imported into Australia has been completed and a suitable text to accompany the table is in course of preparation.

(*b*) *Silvicultural Tests.*—An examination has been made of the trend of compression strength from pith to bark in four logs of *Pinus canariensis* and six logs of Victorian-grown Douglas fir. On six logs of *Pinus radiata*, the compression strength of the full cross section of the tree, tested in log form, has been compared with the estimated strength based on the trend of compression strength from pith to bark as determined from small specimens.

(*c*) *Timber Engineering.*—(i) *Structural Design.*—Compared with previous years more structural investigations were carried out. Various structural designs have been examined, including trusses, purlins, floor and roof beams, and stressed skin wall panels. Some attention has been given to the design of trusses for farm buildings. A number of the structural units designed were subsequently fabricated and proof-tested. One investigation of particular interest involved the construction of a one-fortieth scale model of a projected music bowl. The main structure of the bowl is a network of stressed cables, and tests were made on the model first to find the most desirable shape and then to determine its behaviour under simulated wind loadings. Recommendations were made regarding the arrangement, securing, and jointing of the aluminium-faced plywood with which the bowl is to be sheathed.

(ii) *Connectors.*—The force required to embed 3 and 4 inch alligator connectors and 2½ inch bulldog connectors in partially dried Douglas fir was measured, and tests were made on the completed joints to determine the separate contribution to the strength of each joint of the connector and tie bolt.

(iii) *Nails.*—Lateral loading tests have been made on joints in grey ironbark, jarrah, yellow stringybark, messmate stringybark, and radiata pine. Using various intensities of load, cyclic loading tests have been made on joints of both green and dry radiata pine. Some tests on the resistance to " popping " of annularly grooved nails used in fixing wallboard have been completed. Exploratory tests have been made on methods of fastening hardboard and plywood to timber with power-driven staples and various types of nail.

(iv) *Glue.*—The shear strength of joints made with hardboard glued to hardwood is being investigated. A few long-term loading tests to compare glued and nailed joints are also being carried out.

(v) *Columns.*—Five additional columns were tested during the year. Of the total of 360 which have been loaded, 283 have failed. It is clear that with columns loaded to 70 or 60 per cent. of the estimated short duration failure load, and either kept green or allowed to dry out, failure usually occurs within a few weeks to a few months. There is evidence of a species difference in time to failure, and the Douglas fir columns tended to last longer than the eucalypts.

There are insufficient data to define similar trends in the columns erected dry, but although only the 70 per cent. loading has been applied it is clear that the period before failure is considerably longer than with green or drying specimens.

(vi) *Scantling.*—The results of the work on 4 by 2 in. jarrah scantlings have been published. In cooperation with the South Australian Woods and Forests Department, the distortion of radiata pine scantlings on drying is being studied. The results indicate that when dried in 2-inch flitches and resawn into scantling sizes, radiata pine shows less twist, bow, and spring, than when cut to size green from the saw and subsequently dried. Distortion decreased with distance from pith.

Bending tests have been made on 180 pieces of radiata pine scantlings to determine the influence of various defects in this timber.

(vii) *Poles.*—Jarrah, yellow stringybark, and radiata pine poles in the green condition were tested together with associated small clear specimens. In addition, tests have been made on messmate stringybark and yellow stringybark poles, some of which were desapped, and all of which were dried and subsequently rewetted to simulate service conditions for the butt sections. The type of failure in the seasoned and rewetted poles appears to be different from that of the poles tested green.

The stress distribution through a cross section of a pole under test has been examined and compared with the stress distribution of the same pole after turning in a lathe, of a beam of octagonal section cut from the pole, and of a beam of square cross section.

Preliminary tests have been carried out on radiata pine to study the effect on strength and stiffness, of steaming and of Boultonizing small clear green specimens, and also of a standard creosote preservative treatment of small clear dry specimens.

6. TIMBER PRESERVATION.

(Division of Forest Products.)

(*a*) *General.*—In addition to much general advisory work, problems of the rapidly developing preservation industry have made heavy demands on senior staff. Assistance has been given in the design and costing of low pressure plants for treatment of fence posts, hop poles, and colliery timbers; standard plants for treatment of transmission poles, building timbers, etc.; and high pressure plants for preservative oil treatment of eucalypt sleepers and crossarms. Two experimental plants to operate at pressures up to 1000 lb./sq. in. have also been designed for Asian countries under the Colombo Plan technical assistance scheme.

(*b*) *Field Tests.*—Work has included inspection of existing tests and the treatment and installation of new material. Over 200 pole stubs, pressure treated with nine preservatives, have been despatched to north Queensland for installation in areas of high termite hazard. High pressure treatment of approximately 700 rail sleepers for service tests in New South Wales and Queensland has commenced in the Division's experimental cylinder. With these additions, the total number of sleepers in tests will exceed 12,000 in more than 30 localities in all States.

(*c*) *Fence Posts.*—Cheap and simple methods for the preservative treatment of round fence posts, shed poles, &c., have been demonstrated to farmers at field days and agricultural shows. Treatment of green round posts by the simple sap replacement method has been investigated, including the effect of timber species, preservative salt, weather conditions, and the period between cutting and treatment. With eucalypt posts, high retentions and satisfactory distribution of toxic components in the sapwood have been obained with copper-chrome-arsenic preservatives.

(*d*) *Factors Responsible for Durability of Heartwood.*—Study of toxic substances in durable timbers has continued, with the Division of Entomology cooperating in termite tests. Tectoquinone in the concentration normally present in teak has proved non-toxic to wood-destroying fungi and termites, though in the latter case it is repellent and hence contributes to durability. Decay resistance of teak heartwood typically increases with distance from the pith, but the number of non-durable growth rings varies widely between trees.

Further studies with tallowwood have shown that the ether extract is toxic to termites, but the highly fungicidal methanol extract is not, which indicates that different compounds confer decay and termite resistance. Chromatographic separation of teak and tallowwood extractives is proceeding.

(*e*) *Diffusion Treatments.*—Development of cheap diffusion treatments for building and joinery timbers has continued. Patent application has been made for a range of borofluoride preservatives, with or without arsenic, suitable for dip treatment of green timber in very concentrated solutions, followed by block-stacking to permit diffusion of chemicals into the wood. In laboratory tests of these preservatives, control of decay and termites has been equal or superior to that obtained by more costly pressure treatment with a copper-chrome-arsenic preservative. Field tests are in progress to determine the extent of penetration necessary in building timbers to control termites. Semi-commercial tests at sawmills using a non-arsenical borofluoride in dip-diffusion treatment for control of *Lyctus* have given satisfactory results.

(*f*) *Mycology.*—Work on tolerance of fungi to preservatives has continued with special reference to the toxicity of arsenic. A study is being made of strains of *Poria vaillantii* which, under laboratory conditions, can decay wood with very high retentions of copper-chrome-arsenic preservatives.

Reports describing the Division's collections of *Coltricia, Inonotus, Fomes,* and *Fuscoporia* have been prepared. A catalogue of herbarium material is ready for issue.

Laboratory testing of natural decay resistance of eucalypt timbers has continued with emphasis on variations within and between trees of a species.

(*g*) *High Pressure Treatment of Refractory Timbers.*—Treatment for service tests of eucalypt sleepers and cross-arms at pressures up to 1,000 lb./sq. in. has continued. Studies have been made of the treatability at high pressure of karri and brush box and also of timbers from the Philippines (red and white lauan), Tanganyika (*Brachystegia* sp.), and Japan (beech heartwood). Alternating pressures tried on some species were invariably less satisfactory than steady application of pressures up to 1,000 lb./sq. in.

7. TIMBER SEASONING.

(Division of Forest Products.)

(*a*) *General.*—Requests from industry for technical assistance on drying, plant planning, and handling problems remained heavy. Special attention was given to improving the quality of drying in predriers.

(*b*) *Collapse and Recovery.*—A correlation between collapse susceptibility and wood maturity in mountain ash was established. Collapse in the heartwood of head log material was only about half that in butt material. That in sapwood was not more than one-third that in the adjacent heartwood throughout log lengths. Significant sapwood collapse appeared to be confined to butt log material. Reconditioning greatly diminished but did not remove these differences.

A 6-hr. steaming of green mountain ash reduced air- and kiln-drying times by approximately 25 per cent. without impairing colour or size after reconditioning. Steaming periods of 12-48 hr. further reduced drying times, markedly increased collapse and collapse permanence, but darkened colour. A second delayed reconditioning proved of great value in removing collapse in mountain ash caused by reconditioning at too high a moisture content.

Pretreatment with 12 per cent. sodium chloride and 0.01 per cent. hydrochloric acid reduced gross shrinkage in Israeli-grown immature river red gum by 17 per cent. and 8 per cent. of green wood volume respectively but steam reconditioning proved more effective than either of the chemical treatments in removing collapse. It was concluded that sodium chloride acted as both an anti-shrink agent and a collapse inhibitor.

(*c*) *Equilibrium Moisture Content.*—The study of the correlation between wood equilibrium moisture content (e.m.c.) and weather conditions was extended to include the influence of thickness and species variations, and the measurement of seasonal e.m.c. variations in outdoor timber structures was continued. Mountain ash and radiata pine exposed in outdoor sheltered positions in Antarctica showed a 10-14 per cent. moisture content range, but remained constant at 4 per cent. in warmed personnel shelters.

(*d*) *Drying Studies.*—Drying under superheated steam conditions markedly reduced twist in radiata pine weighted with the equivalent of 140 lb./sq. ft. Tenderizing further reduced this fault. Twist was reduced by steaming, and the improved condition was generally retained during storage. Pith-containing material twisted consistently in the one direction but sapwood about equally in both directions. Plantation-grown ponderosa pine case stock was seasoned without difficulty, provided material nearer than 2 in. to the pith was excluded.

Studies on the prevention of end checking in logs and poles were continued. The best of the coatings tried, viz. a self-hardening petroleum jelly, a mixture of this and a hard wax, and a bituminous emulsion, proved particularly good over an effective life of twelve months. Minimum air- and kiln-drying times, and the most satisfactory of other accelerated methods for the seasoning of poles and sleepers to moisture contents suitable for preservative treatments, were determined. The chemical seasoning of joinery quality 5 by 3 in. mountain ash proved highly successful. Kiln schedules for satin box, aglaia, Japanese beech, taun, hickory, and Vanikoro kauri were investigated.

(*e*) *Kiln Design and Equipment.*—Seasoning plant layouts and designs for sawn timber and veneer kilns, laboratory kilns, reconditioners, special driers, and kiln handling equipment were prepared for 58 firms or research institutes in Australia, New Guinea, South Africa, Southern Rhodesia, India, the United States of America, Spain, Ecuador, and Chile. Designs for McCashney wood waste units were prepared for 44 firms in Australia, Southern Rhodesia, and South Africa.

Air circulation and general efficiency tests on kilns and predriers were made for eight firms. Assessments of the relative merits and economics of electrical heating and steam heating using solid-fuel, oil-fired, and electrically heated boilers were prepared. The size range of the screened veneer drier was extended. Design data for two furnace gas kilns were prepared. A bituminous emulsion proved the most effective of eight preparations tested in resisting breakdown of concrete reconditioning chamber surfaces.

8. PLYWOOD INVESTIGATIONS.

(Division of Forest Products.)

(*a*) *Peeling Studies.*—Laboratory investigations were carried out on karri, alpine ash, Vanikoro kauri, radiata, cryptocarya, red silkwood, and ramin. The effect of log heating was studied in karri and red silkwood where temperature sensitivity was observed. On the laboratory lathe the effect of bevel angle was examined, and also the deleterious effects of back bevelling for edge reinforcement. Work on the widths of microbevels which can be tolerated in various species was also initiated. In the assessment of peeling quality, transverse tensile strengths of veneer were compared with peeler check penetration methods.

A modified approach to peeling studies has been adopted on the laboratory lathe with a multiple knife technique, which allows a number of peeling variables to be studied more accurately with better matching in limited material. Lathe work in the field has resulted in the wide adoption of lathe gauges for setting up, and of permanent nose-bar stations, following demonstrations of laboratory developed portable equipment.

(*b*) *Veneer Drying.*—The absence of a laboratory veneer drier restricted species studies, but in visits to plants recommendations were made for improvements to commercial units of various types, and special attention was paid to commercial roller and mesh belt driers in order to improve dried quality. In a commercial cross-circulation roller drier without air reversal, it was found difficult to avoid moisture differences of less than 4 per cent. across the unit at average moisture contents of 10 per cent. Drying problems in screened units included studies of a number of New Guinea species. A practical method of end moisture content prediction was established on mechanical driers not using radiant heating. This method based on temperature difference is also of value for final moisture content determination in compartment units.

The dangers of surface measurements of moisture content of thick veneers immediately after drying, with the use of electrical and hygrometric methods, were confirmed. Serious errors were observed in low-penetration capacity types and also with surface hygrometers.

(*c*) *Gluing Research.*—(i) *Tannin-formaldehyde.*—Wattle tannin required substantially less fortifying resin to produce a satisfactory bond than the mangrove tannin extracts previously examined. The defect of long setting time of phenolic fortifying resins was overcome by using phenol-resorcinol-formaldehyde co-polymers. Excessive penetration of veneers, a fault common with tannin adhesives, was also very largely overcome on a laboratory scale by a pretreatment with formaldehyde and also by use of a suitable filler.

A survey of gluing properties of various wood species was commenced and a commercial test was carried out with karri veneer, which, although not completely satisfactory, was very promising. Effects of post-press curing of tannin adhesives were examined, and results were favourable.

(ii) *General.*—The effects on silky oak of several variables with the use of long assembly adhesives were studied. The value of heavy glue spreads and the importance of a relatively high moisture content for best results were indicated.

Studies of methods of inducing gluing case hardening were continued, and coachwood showed extreme sensitivity at 145° C.

(*d*) *Other Investigations.*—The temperature distribution in both steam and liquid heated presses was investigated and advice given on temperature problems and control techniques.

The gluing of a number of commercial veneer species which had been treated by instantaneous dip methods to suitable loadings with water soluble preservatives was investigated. Results showed distinct individual species reactions to various preservatives and glues. In some cases, results for both wet and dry tests were completely satisfactory, whereas in other cases specification requirements could not be met. A number of glue line additives were tested and arsenic trioxide generally gave satisfactory adhesion.

Studies of veneers immunized against *Lyctus* with boron were made to evaluate the variables of moisture content, pressing time, and a number of other factors on wet string. Results showed relatively low sensitivity to moisture content but a high sensitivity to curing time.

9. UTILIZATION.

(Division of Forest Products.)

(*a*) *Timber Uses.*—Information was supplied on the suitability of timbers from 178 uses, and advice given on the properties and uses of 160 species.

(*b*) *Manufacturing Processes.*—The division provided assistance and information to sawmills designed for sawing general-purpose hardwoods and small hardwoods, pines, furniture woods, mining timbers, eucalypts in Hawaii, and tropical woods in the Philippines. Layouts were prepared for several moulding plants, a finger-jointing plant, a cabinet manufacturing plant, a joinery factory, and timber distributors' yards. The capabilities of a wide range of equipment available in Australia or obtainable from abroad were reviewed. Breaking-down procedures studied at hardwood sawmills disclosed the possibility of attaining a better work balance between breaking-down and the subsequent sawing on breast benches. Sawmilling techniques abroad and in Australia were compared to indicate benefits that may follow the adoption of overseas headsawing practices.

(*c*) *Sawing.*—Two sawmill studies to determine the effect of the speed of circular saws on power consumption, saw stability, and saw durability were conducted. When the rim speed was reduced from 10,000 to 7000 ft./min. the improvement was outstanding.

Observations of the wear of lacquer on saw teeth, with particular application to a study of clearance angle, were continued. An idealized tooth shape without top bevel was adopted, and a measuring microscope used to determine the amount of wear. For a 3-in. depth of cut and feed speeds up to 250 ft./min. a clearance angle of 6° was shown to be the minimum allowable. More clearance seems necessary for 12-in. depths of cut.

The pendulum dynamometer for studying the action of a single saw tooth has been further modified in efforts to measure forces in all three directions.

A chain saw of advanced type was obtained from overseas, and testing of its performance under Australian conditions has commenced.

(*d*) *Waste Utilization.*—In an investigation of sawdust as a soil improver, a further sampling of incubated sawdust soil mixtures after 616 days showed that 41-48 per cent. of the nitrogen which was taken up earlier had been released again as nitrate. Deleterious effects of fresh radiata pine and eucalypt sawdusts on the development of commercial vegetable seedlings appeared to be due to phenolic substances. These effects were avoided by solvent extraction of the sawdust, or more simply by addition of lime followed by leaching with water, a process easily applied in practice.

The utilization of sawdust and shavings was encouraged by providing information on fuel value, briquetting, manufacturing of charcoal and supplementary stock foods, and particle-resin mixtures for the manufacture of boards. Short-length residues were tried for finger jointing, and experiments undertaken to determine the efficacy of various profiles, types of glue, and end pressures during assembly on the strength of joints in seven different timbers.

XV. BUILDING.

1. GENERAL.

It is only in comparatively recent times that the methods of scientific investigation have been applied to the development and improvement of both domestic and industrial building structures.

The building research work of the Organization is undertaken mainly by the Division of Building Research, Highett, Victoria, which collaborates closely with the Commonwealth Experimental Building Station of the Commonwealth Department of Works in New South Wales. The primary responsibility of the Division of Building Research is long-term research. In practice, the major part of the Division's activities is devoted to research on materials, but work is also being undertaken on architectural acoustics and and the thermal characteristics of buildings.

Work on timber for constructional purposes is concentrated in the Division of Forest Products (see Chapter XIV.). Work on building foundations is undertaken by the Division of Soils (see Chapter II., Section 7), and work on cement and ceramics by the Division of Industrial Chemistry (see Chapter XVII., Section 3).

Division of Building Research.—The year has seen further increases in the steadily growing co-operative research programmes undertaken by the Division in conjunction with various industrial establishments.

A new co-operative investigation has been initiated on the use of ordinary household hot-water heaters, fired by brown coal briquettes, for space heating as well as water heating in lower- and medium-price houses. The State Electricity Commission of Victoria is contributing £2,000 and seconding an officer to the Division for two years to assist with this project.

Good progress has been made in the co-operative project financially supported by the paint manufacturers in New South Wales and Victoria (see Section 10 of this Chapter.)

The co-operative research on fibrous plaster being financially supported by the Associated Fibrous Plaster Manufacturers of Australia is also continuing.

The building industry is becoming increasingly aware of the value of research. At a " Round Table on Waste in the Building and Construction Industry " convened by the Australian Institute of Builders, a resolution was adopted that " finance for basic research as well as for research into the application and quality of building materials should be made available by industry ". Members of the Australian Clay Products Association attending their annual conference also visited the Division during the year. Special effort is being devoted to maintaining this liaison with industry.

Officers of the Division delivered extension lectures at the Universities of Sydney and Melbourne and at the Royal Melbourne Technical College. Lectures were also given to students of architecture at the University of Melbourne.

2. ARCHITECTURAL ACOUSTICS.

(Division of Building Research.)

Investigation has continued on the acoustical characteristics of auditoria. From this investigation it now appears that the acoustical preferences of the individual members of audiences range quite widely, and that, unless the acoustical deficiencies of a hall are extremely bad, the ordinary listener is completely unaware of them. Listening tests with speech and music having artificial echoes and with recordings from different halls have been made, and these give a similar picture of broad tolerance. In parallel with this work listening tests have continued with electronically produced sounds and artificial echoes. A hypothesis has been developed which explains nearly all of the observations of such listening tests made both in Australia and overseas.

The study of sound transmission along acoustic ducts with discontinuities, such as bends and changes in cross section, has continued with work on plates with orifices and continuous porous membranes across the duct. The reflection and transmission characteristics of these types of discontinuity have been measured and theoretical studies made of combinations of them. The basic purpose of this study is that, as many commercial absorbents are combinations of a number of these types of structure in series, the design of new absorbents would be facilitated if this basic knowledge were available.

3. BITUMINOUS MATERIALS.

(Division of Building Research.)

The effects of the materials used and of the design of bituminous flat roof membranes on their performance have been examined both in the laboratory and by field trials in which experimental membranes have been laid and their performances observed. These trials have yielded useful comparisons of various roofing systems and the data obtained are being analysed.

(*a*) *Standard Specifications for Roofing Felts.*—The Division is represented on the Committee of the Standards Association of Australia that is engaged in drawing up standard specifications for composition and performance of bituminous roofing felts. Draft specifications for saturated and coated organic fibre felts have been issued for comment.

(*b*) *Shrinkage of Roofing Felts.* — Considerable shrinkage of paper-based roofing felts can occur in service, and it is believed that this is associated with changes in moisture content and the large variation in viscosity of the bitumen adhesive with changes in temperature.

Raw, saturated, and coated felts were exposed to the weather, and it was observed that the presence of the saturating bitumen had little effect on the movement measured, which was of the same order as that of the raw felt. However, it was found that felts laid loose moved much less than those fixed with bitumen. The movement of asbestos felts was considerably less than that of paper felts, but was greater than that of glass fibre felts.

(*c*) *Glass-fibre Base Bituminous Roll Roofing.*—Glass-fibre tissues used as a base for roll roofing cannot be saturated in the same way as organic fibre or asbestos felt owing to the very open construction of the tissue, hence only a blown or coating bitumen is used in its manufacture.

For a full-scale trial a three-layer membrane of a number of commercially available glass fibre roofings was installed on a strawboard roof deck. The various glass fibre roofings are being compared with one another and with a saturated asbestos felt section incorporated in the membrane. In the same trial the relative merits of three different methods of attachment of the first layer of the membrane to the deck are being compared.

(*d*) *Addition of Fillers to Bituminous Coatings on Roofing Felts.*—The merits of using bituminous coatings containing inorganic fillers are being examined from the point of view of mechanical stability, durability, and water penetration. Overseas research shows that the filler improves the mechanical stability of the coating and that filled coatings exposed at a considerable angle to the horizontal are more durable than unfilled coatings of bitumen alone.

4. CLAYS AND CLAY PRODUCTS.

(Division of Building Research.)

(*a*) *Regional Studies of Australian Clays.*—Up to the present studies of clays from Brisbane, Sydney, Perth, Tasmania, and central and western Victoria have been completed, and that of clays from Melbourne and adjacent areas has been begun.

Progress has been made in the study of the clays of the Melbourne and adjacent areas. The mineralogical study of the roofing tile clays is nearing completion, and most of the differential thermal and particle size analyses of all clays of the area have been made.

(*b*) *Expansion of Clay Products.*—The work on the expansion of bricks and roofing tiles when exposed to water has been extended to other types of clay product and to the whole of the Australian clay products industry also.

From the expansion of individual bricks and experimental brick walls the extent to which brickwork may be expected to expand in practice has been calculated for the various types and varieties of brick examined. The reasons for expansion and ways of overcoming it within the bricks themselves are being investigated.

(*c*) *Durability of Clay Roofing Tiles.*—The study of the deterioration of clay roofing tiles, of particular significance along Australian sea fronts, has been continued. A study of the effectiveness of a modification in the design of the present Marseilles-type tile in reducing deterioration by salt solutions has been started. Results obtained after exposing the tiles to the salt solutions for a period of one month on an experimental roof show that the modified tile undergoes significantly less deterioration than the unmodified one.

(*d*) *Industrial Potentialities of Clay Materials.*—During the year 40 clays and shales from various parts of Australia, New Guinea, and Fiji have been received for investigation. Pilot plant and laboratory studies have been completed on most of them, and recommendations made concerning their suitability for bricks, tiles, pipes, &c.

(*e*) *Plant and Equipment.*—Research has continued to assist in improving designs of kilns employing both coal and oil firing. Over the past year the Division has given much consideration to improving the extrusion of clay columns for various types of product by avoiding the necessity for lubrication and eliminating lamination in the extruded body. A patent has been applied for a special type of rubber sheet developed by the Division for lining extrusion dies, which permits extrusion without lubricating with oil or water.

5. CONCRETE INVESTIGATIONS.

(Division of Building Research.)

(*a*) *Theory of Rupture of Concrete.*—In the past the stresses and strains which actually cause cracking of concrete under combined short-term loads have been studied, and a criterion of failure has been established which has received qualitative confirmation by more recent overseas work. Subsequent studies have sought to determine whether prolonged loading modifies the criterion of failure previously established. Tests of plain concrete beams loaded for two years have shown no sign of any modification of the conditions governing failure, and there has been no indication that the ultimate strength is reduced by prolonged loading.

(*b*) *Prehardening Cracks in Concrete.*—Prehardening cracks, also known variously as " presetting " or " plastic " cracks, usually form within an hour or so of pouring but may not be easily visible unless the concrete is subsequently exposed to fairly rapid drying. It has now been established that the cause of these cracks is differential rates of settlement of the components of the concrete when they settle over some obstacle such as reinforcement or a large piece of aggregate.

(*c*) *Revibration of Concrete.*—Tests of the effect of revibration or delayed vibration of concrete were begun as part of the study of prehardening cracks, as a possible method of eliminating such cracks. Fluid concretes, for which immediate vibration produces no increase in strength and may encourage segregation, show gains in strength of one-sixth to one-fifth if the vibration is delayed until initial set.

(*d*) *Calcium Silicate Hydrate.*—Although calcium silicate hydrate is not yet being produced commercially on any large scale in Australia it is in many ways an attractive form of lightweight concrete for the production of precast units. Extensive studies have been made of the influence of autoclaving temperatures and times and moulding pressure on the properties of this material at different densities.

6. GLASS AND GLAZING.

(Division of Building Research.)

(*a*) *Cracking of Glass.*—The cracking of coloured glass sheets installed in non-window areas of curtain walls is caused mainly by shading of the edges from direct sunlight by the beads and glazing compound holding the glass in place. Laboratory determinations of the temperature difference necessary to crack strips of glass show that glass that has been heat toughened has a strength far in excess of any of the others tested, and such treatment is obviously the safest way of avoiding cracking.

To determine quantitatively the thermal gradients that occur in service, temperature measurements were made on glass of various colours in simulated spandrel panels. It was concluded from these that there is little risk of cracking of light-coloured glasses because of thermal gradients at the edge, but that the risk increases considerably for less reflective colours.

(*b*) *Glazing Compounds.*—Following exploratory tests on suitable methods of test for evaluating the relative performance of non-hardening glazing compounds, a shear test and a tensile test were adopted for further investigation. The materials tested included those based on thiokol, polybutene, and vegetable oil vehicles. The thiokol materials have so far given outstanding performance except where glass-thiokol interfaces were exposed directly to the sun.

7. GYPSUM PLASTER INVESTIGATIONS.

(Division of Building Research.)

Investigations are being made into the fundamental physical chemistry of calcium sulphate hemihydrate (gypsum plaster) as well as more immediately applied problems such as the mechanical properties of plaster for use in load-bearing walls and problems associated with the manufacture and decoration of fibrous plaster sheets.

(*a*) *Physical Chemistry of Plaster.*—The work on the physical chemistry of plaster is continuing in the direction of a study of the relationship between the physical properties of plaster and its microstructure, the vapour pressure relationship between the various forms of calcium sulphate, and the mechanism of setting.

Work has been commenced on a study of the effect of variations in calcination conditions on the properties of the finished plaster.

Work on the absorption of atmospheric moisture by plaster, which is important in determining safe storage conditions, has shown that at relative humidities up to 76 per cent., plaster is not hydrated (set) by the water vapour of the atmosphere, i.e. plaster can be safely stored at such humidities. At higher humidities slow hydration takes place, e.g. at 85 per cent. relative humidity approximately 20 per cent. of a plaster sample was hydrated to gypsum in twelve months.

(*b*) *Pilot Plant.*—Chemical engineering studies of the manufacture of plaster from gypsum have already resulted in new improved designs for several items of plant for which patent applications have been lodged or are pending.

(*c*) *Structural Gypsum Plaster.*—Since 1945 there has been a unique development in Australia in the use of large precast units of gypsum plaster for the load-bearing walls of veneer-type houses. Studies have been made of the factors which affect the strengths of the cast gypsum and of the deformation of the material under long-term load.

(*d*) *Fibrous Plaster Investigations.*—Co-operative investigations being undertaken for the Associated Fibrous Plaster Manufacturers of Australia have continued.

An examination is being made of problems associated with improving the appearance of plain flush-jointed walls and ceilings. Glancing light can cause unwanted irregular shadows that destroy the impression of flatness of the surface. Research has been concentrated on obtaining pictorial evidence of the effect of glancing light on the appearance of flat surfaces of set plaster, fibrous plaster, gypsum board, and hardboard.

8. LIGHTWEIGHT AGGREGATES.

(Division of Building Research.)

There is a pronounced world-wide trend to lighter building construction, and one of the most promising ways of achieving this is by the use of lightweight aggregates in concrete and plaster for structural and fireproofing purposes. Research on the production and properties of these lightweight aggregates has been continued, notably on bloated clay and shale for concrete and on perlite for both concrete and plaster.

(*a*) *Perlite.*—Perlite is an ultralightweight aggregate made from volcanic glasses by rapidly heating small particles of the ground ore to temperatures of 900-1,100° C. A survey has been made of the perlite resources of Australia and these have been studied in some detail. Much testing has been carried out for established and prospective manufacturers of perlite. Experimental studies of the mechanical and physical properties of perlite plaster and concrete have largely been completed, and only the long-term studies of the effect of the expansion of perlite plaster are still continuing. The most recent experimental work has confirmed that this long-term expansion, which was first discovered by the Division some years ago, will not cause any structural damage or deformation in normal buildings.

(*b*) *Expanded or Bloated Clays and Shales.*—The work of the Division in the field of expanded clay and shale aggregate during the past year has been mainly on testing of raw materials and advising on the setting up of commercial plant. A new oil-fired rotary kiln has now been in almost continuous use since its installation, just on twelve months ago, testing clays and shales from Sydney, Melbourne, Hobart, and Adelaide for intending producers.

In the absence of a commercial supply of the material no large project on concrete incorporating these medium-weight aggregates has been possible, but some interesting exploratory tests on bond strength and rain penetration have been done with aggregate produced in the pilot kiln.

9. Lime and Lime Products.

(Division of Building Research.)

With the completion of the studies on the correction of unsoundness in magnesium limes formal research studies on lime have been discontinued until such time as the demand for further work arises. The survey of the lime industry and its resources is being continued as opportunity permits, and advice and assistance to manufacturers and those interested in lime and its products are still given upon request.

10. Paint on Plaster Investigations.

(Division of Building Research.)

With the assistance of the Australian paint industry work is now in progress on the problems of the decoration of plaster surfaces in general. The problem first studied was "sulphide staining". It has been determined that this defect is caused by lead in the paint interacting with hydrogen sulphide in the atmosphere. To prevent danger of staining the amount of lead in the paint must be kept below 0.004 per cent.

Laboratory experiments show that a solution of 7 per cent. of the disodium salt of ethylene diamine tetraacetic acid in 10 volume hydrogen peroxide gives more lasting results in removing existing stains than does hydrogen peroxide alone, but the treatment is effective only if the paint film contains less than 0.5 per cent. lead.

11. Thermal Investigations.

(Division of Building Research.)

The mathematical treatment evolved by the Division for calculating temperatures inside buildings exposed to variable external conditions has been subjected to verification by a large-scale test using two buildings which are stylized copies of houses, one being of conventional timber construction with tiled roof and suspended timber floor and the other a timber house of "Solar" design having a north-facing glass wall, flat roof, and concrete floor on the ground. The general agreement between the calculated and observed temperatures was found to be very good, generally far better than might be expected when the likely inaccuracies in the assumed thermal properties are considered.

The calculation technique was useful also in studying the probable temperature distributions in a new arch dam at present being designed by the Commonwealth Department of Works for the Cotter River, Australian Capital Territory.

XVI. WOOL TEXTILES.

1. General.

With wool holding such a prominent position in Australia's economy, it is appropriate that the Organization should be paying special attention to the problems of the wool industry, particularly in their relation to the increasing competition represented by the synthetic textile fibres.

The major aims of the Organization's wool textile research are: (i) to increase the knowledge and understanding of the complex structure of the wool fibre and its physical and chemical properties; (ii) to use this knowledge to improve wool as a textile fibre, to improve technology in wool processing, and to utilize by-products more fully; (iii) to improve machinery used in wool textile manufacture. In these ways it is hoped to preserve wool's unique position amongst the world's textile fibres.

This work is complementary to the research in sheep husbandry described in Chapters V., VI., and VII., which is aimed at increasing the quality and production of wool at the pastoral stage.

The Organization's wool textile research is distributed among three Wool Textile Research Laboratories, as follows:

- (i) The Melbourne Laboratory at Parkville is responsible for research on the structure and chemistry of wool and on some related wool processes.
- (ii) The Geelong Laboratory at Belmont is primarily responsible for technological investigations.
- (iii) The Sydney Laboratory at Ryde carries out research on the physics of wool and on the physical and engineering aspects of wool processing.

The overall policy of these Laboratories and the co-ordination of wool textile research is the responsibility of the Wool Textile Research Committee. This Committee is comprised of the Officers-in-Charge of the three Laboratories, and it constantly reviews research programmes to ensure that for each project the best use is made of available personnel and facilities. It also arranges if necessary for joint study on a project at two or all three of the Laboratories. The work of the Wool Textile Research Laboratories is described in this Chapter.

The Division of Industrial Chemistry has continued a study of the constituents of wool wax and possible ways of utilizing them or their derivatives (see Section 4 of this Chapter). It is also studying the structure of proteins in relation to wool (see Section 10 of this Chapter). The Division of Entomology is continuing to study the digestive processes of wool-eating insects and larvae (see Chapter IX., Section 2 (*a*)).

Wool Textile Research Laboratories.—The projects pursued in the Wool Textile Research Laboratories during the past year are essentially the same as those studied previously.

A record quantity of SI-RO-MARK branding fluid has been marketed by the 27 firms which are now authorized to use the certification mark, and although unsatisfactory fluids are still used by some growers and in sale yards, the problem of non-scourable brands in wool has been largely overcome. The solvent degreasing process is now being used commercially and the process is being investigated further on a pilot-plant scale. Research is in progress on an alternative process to worsted carding and an auto-control unit for use on the Noble comb has been developed. The use of the SI-RO-MOTH'D process involving dieldrin for mothproofing has extended to the United States of America, the United Kingdom, and Japan. A major advance during the year has been the development of the SI-RO-SET process for the durable creasing of trousers or pleating of skirts. Investigations on hospital blankets have been extended and studies on the nutrition of the footrot organism are continuing in association with an officer of the Division of Animal Health and Production in Sydney.

The Officer-in-charge of the Melbourne Laboratory was appointed to represent the Organization on the newly formed Australian Wool Testing Authority. The Authority will be accommodated adjacent to the Melbourne Laboratory. This arrangement will enable close liaison to be maintained with the Wool Textile Research Laboratories. Technical information on the properties of wool will be drawn on freely by the Authority to assist in developing reliable testing methods. The Authority in turn will be able to provide the C.S.I.R.O. Laboratories with information on particular samples of wool to assist with the research work.

The Officer-in-charge of the Geelong Laboratory participated in a conference in London organized by the International Wool Secretariat at which the development of " easy care garments from wool " was the main theme for discussion. During this visit several papers were presented on behalf of the Laboratories at the International Wool Textile Wool Organization Technical Committee Meeting in Paris.

2. RAW WOOL.

(Wool Textile Research Laboratories.)

(*a*) *Sampling of Wool.*—For estimating the yield of clean fibre in greasy wool, or moisture in scoured and carbonized wools, samples are conveniently taken from the bales by means of a core borer. In this method a metal tube, fitted with a cutting tip, is attached to an electric drill and driven into the bale. The wool sample is recovered from the tube. An improved sampling device has now been developed, termed a " pressure corer ", which is pushed into the bale by hand without mechanical rotation. It is cheaper than the core borer, and simpler and more convenient to use, since it dispenses with the electric drill and allows the wool sample to be pushed through the tube into a plastic bag attached to the end of the tube. Special attention has been paid to the design and sharpening of the tip.

(*b*) *Branding Fluids.*—It is estimated that SI-RO-MARK branding fluid has been used on about 90 per cent. of the branded sheep in Australia. The 118,000 gallons produced during the past year included 46 per cent. blue, 38 per cent. red, and 16 per cent. green fluid. The possibility is being explored of introducing purple as a fourth colour into the range of available fluids. Black is not included in the range owing to the risk of confusion with the unscourable tar brands.

(*c*) *Solvent Degreasing.*—The solvent degreasing process is now being operated commercially in Australia in one plant on a three-shift basis, and construction of a plant in the United Kingdom is about to commence.

Pilot-plant trials indicate that woven nylon mesh may have a longer life than wire mesh as a conveyor and that fewer jets operating at an increased pressure may be satisfactory. If adopted, this arrangement would allow the plant to be shortened. The solvent degreasing process has been shown to improve the tear, produce less nep, and, in some instances, to yield top of longer mean fibre length than soap-soda scouring.

(*d*) *Burr in Wool.*—The Laboratory's discovery of the protective effect on wool of adding non-ionic detergent to the sulphuric acid bath used in carbonizing is now widely employed in the Australian industry and has been confirmed overseas. However, the concentration of sulphuric acid normally used in European mills is lower than that in Australia, and damage to the wool is therefore less severe. It should be possible, by protecting the wool with wetting agent, to increase the acid concentration and cheapen the processing by increasing the throughput of wool.

Two different types of damage are produced in wool by sulphuric acid. That produced by heating wool in dilute acid increases the alkali solubility and trypsin digestibility but does not appreciably affect the strength. The other type occurs when wool is saturated with dilute sulphuric acid and then heated in an oven in a draught of air to evaporate the water and concentrate the acid, as under industrial conditions. This causes little change in the alkali solubility but lowers the mechanical strength appreciably.

3. FLEECE BY-PRODUCTS.

(Wool Textile Research Laboratories.)

The flotation plant for recovering lanolin has been modified to give greater production and more consistent performance, and the improved machine is now being tested by a firm engaged in the refining of lanolin.

The colour of the lanolin produced by the solvent degreasing process is inferior to that produced by soap-soda scouring. However, the colour is improved by hydrogen peroxide bleaching or by treatment with the adsorbent, fuller's earth.

4. DERIVATIVES OF WOOL WAX AND SUINT.

(Division of Industrial Chemistry.)

The potential output of wool wax from the Australian wool clip alone is between two and three times the present wool production of hard waxes from natural sources. In seeking outlets for wool wax, potentially larger fields of use must therefore be sought. Esters are used as plasticizers in the plastics industry and accordingly a range of esters has been prepared from the unfractionated acids from wool wax. Their use as secondary plasticizers for polyvinyl chloride has been examined. Mechanical performance was maintained in replacing up to 30 per cent. of the dioctyl phthalate customarily employed, but each ester tested showed some exudation which indicated limited compatibility. A method for the separation of the acids into their three main chemical types has been developed. Investigation of the composition of unsaponified wool wax is being continued.

Lanosterol is obtained in a condition of near purity during the commercial production of cholesterol from wool wax, and the chemistry of this interesting triterpene is being extended. In seeking its conversion to hormone-like chemicals, long-range interaction of substituent groups was encountered. It was found that carbonyl groups may aid the hydrolysis of distant ester groups, which would otherwise be too heavily hindered to react.

5. WOOL TEXTILE PROCESSES.

(Wool Textile Research Laboratories.)

(*a*) *Yarn Manufacture.*—Development of the converter system to replace worsted carding has continued. The prototype unit has been used to process several thousand pounds weight of wool at rates up to 70 lb. per hour, and has been shown to handle soap-soda scoured wool as well as solvent degreased wool. Removal of vegetable matter is the major difficulty, and several methods of dealing with this problem are being explored.

Wool losses in worsted carding are being assessed for both soap-soda scoured and solvent degreased products, and these studies are being related to similar studies on the new converter system which causes considerably less loss of wool.

Solvent-degreased wool can be carded at much higher rates than soap-soda scoured wool. In one trial the rates were 92 lb. per hour and 40 lb. per hour respectively, and the corresponding tears 14.1 and 11.6. Less top is produced, however, at high carding rates, but the mean fibre length is unaffected.

The Noble comb autocontrol unit has been considerably simplified and the electronic control replaced by a comparatively simple system of microswitches. A local firm is to manufacture these units and it is expected that the device will be widely adopted both in Australia and overseas.

(*b*) *Felting.*—Following the demonstration that crimpless wool from the lustre-mutant Merino sheep at the Sheep Biology Laboratory at Prospect, New South Wales, possesses marked felting properties, samples have been distributed to firms and laboratories which are interested in testing its commercial possibilities.

(*c*) *Oiling.*—Investigations continue on the velocity-friction and aging characteristics of cheap alternatives to the conventional combing oils. Drafting force measurements are used to assess the suitability of the preparations and those showing promise are subjected to processing trials under mill conditions.

(*d*) *Dyeing.*—The melange printing process for worsted sliver is now being used on a large scale and assistance has been given to several firms wishing to employ the improved technique. Extension of the process to fabric printing is being investigated. Improved rate and evenness of dyeing are obtained if wool fabric is previously exposed to ultraviolet irradiation. The exposure time and cost of electric power are at present too high for the process to be attractive, but if developed further it may find application, for example, in pattern printing. Exposure to ultraviolet irradiation also confers some shrinkproofing effect. A new method of dyeing has been discovered which requires only a few minutes' immersion of the wool in a solution of the dyestuff in an organic solvent. Excess dye solution is squeezed out of the wool and solvent remaining is recovered from the wool by heating.

6. FINISHING PROCESSES.

(Wool Textile Research Laboratories.)

(*a*) *Shrinkproofing.*—Greater effort has been devoted to research on shrinkproofing than in previous years. Ethanol extraction of wool has been shown to produce better shrinkproofing, not only when resins are used in the subsequent treatment, as previously reported, but also with shrinkproofing reagents which chemically modify the fibre surface. The ethanol extraction removes a small amount of wax from the wool, the composition of which is being studied. However, ethanol extraction is an unsatisfactory industrial process, and alternative methods of pretreating the wool are being sought.

One very effective method of shrinkproofing wool is to synthesize polyglycine on the surface of the fibres. Deposition of this polymer has been accomplished from organic solvents, but these could not easily be employed in the textile industry and the possibility of depositing polyglycine or some related compound from aqueous solution is being investigated.

Shrinkproofing based on the use of alkali in concentrated salt solution has now been extended to oxidizing agents. Rapid shrinkproofing has thus been obtained without fibre damage, and the method may find application in the treatment of wool tops. It has already been applied to hospital blankets which are being subjected to repeated laundering. SI-RO-FIX-treated blankets are also being tested in the same experiment.

A method has been devised for removing and analysing scales, to determine the effects of various shrinkproofing processes on the surface layers of wool fibres. This method has shown that the scales of untreated wool contain less glumatic acid and aspartic acid and more proline than the rest of the fibre. This may account for the lower reactivity of the scales compared with the cortex of the wool fibre.

(*b*) *Mothproofing.*—The SI-RO-MOTH'D process of mothproofing with dieldrin has become widely used in Australia and the method is becoming very popular also in other countries. Considerable assistance has been given to firms in various parts of the world wishing to adopt the process. The most attractive feature of this method of mothproofing is the low cost. Goods may be treated for less than 1*d*. per lb.

Attempts to stabilize the wool fibre against biological and chemical attack by treating it with carbodiimides to introduce new peptide cross-links were only partially successful.

(*c*) *Anti-bacterial Treatment.*—Examination of samples of dust collected in hospital wards and in the operating theatre has shown that this material consists mainly of cellulose. Wool represents only a very minor proportion of the total fibre and is thus likely to be insignificant as a cause of cross-infection in hospitals. Nevertheless, like other items in the ward, wool blankets become contaminated, and non-damaging methods of cleaning and sterilizing blankets are being examined.

(*d*) *Permanent Pleating.*—Chemical changes found previously to underlie the permanent creasing of wool fibres have been the basis of the development of a commercial method of permanent creasing known as the SI-RO-SET process. The goods are sprayed with a dilute solution of ammonium thioglycollate before the final steaming or pressing, and the resulting creases or pleats are then resistant to normal wear, rain, and drycleaning, and even to hot soap solution. In Australia, eighteen firms were licensed to use the process within six months of releasing the details. An officer of the Geelong Laboratory has been stationed in London to assist with the industrial application of the process in the United Kingdom and on the Continent, and the Australian Wool Bureau is sponsoring a visit by two members of the research staff to New Zealand where they will assist with the initial technical development of the process.

There is scope for further investigation to improve the retention of pleats in light-weight cloths and to increase their wrinkle resistance, and to develop finishing treatments which confer "wash-and-wear" properties on wool garments. Studies are in hand on the effect of fibre type, yarn, and cloth structure on pleat retention and wrinkle resistance and on the mechanism by which felting destroys SI-RO-SET creases. A technique has been developed for embedding and sectioning creased cloth and this has allowed an estimate to be made of the range of strains on fibres in the region of the crease. This is important because chemical setting agents are usually tested by observing their effect on single fibres under strain. By observing the movement of marked fibres in the region of a crease under the stereomicroscope it has been possible to follow their movement during felting. This has established that fibre movement destroys the crease even though the amount of felting would not normally be sufficient for detection by any change in the area of the fabric. A highly efficient shrinkproofing process is thus required in an all-wool cloth to achieve a crease which is fast to washing.

The fate of thioglycollate sprayed on wool fabric has been studied by applying preparations containing radioactive sulphur. It has been shown that none of the thioglycollate is volatilized during pressing with a steam iron but almost all is removed by washing with water.

7. PHYSICS OF WOOL AND FIBRE ASSEMBLIES.

(Wool Textile Research Laboratories.)

(*a*) *Mechanical Properties of Single Fibres*.—Under certain conditions of heating and steaming or chemical action a stretched wool fibre will retain a proportion of the original extension which is fast in varying degrees to further wetting and heating. A broad classification of "permanent" and "temporary" set is given depending on whether the set withstands boiling water. Permanent setting is important in wet finishing operations such as blowing and crabbing, and in SI-RO-SET durable creases. Temporary set is achieved in domestic pressing and creasing operations and when a fabric becomes wrinkled during wear. Permanent and temporary set in single wool fibres are therefore of immediate practical as well as of great theoretical interest.

Studies in permanent set have shown considerable variability between individual fibres within a fleece and between wool types and sheep breeds. Fine fibres can be set better than coarse fibres. A positive correlation has also been established between the setting and supercontraction properties of a fibre and this, together with the relationship between setting and the tension within a fibre, is helping to explain how set occurs.

The changes in dimensions of a wool cloth during the manufacture of garments due to steaming, pressing, or variation in the relative humidity, sometimes cause serious difficulties. Some of these changes are due to failure to remove permanent or temporary set in the fabric. Others are related to the cloth structure and are observed when the relative humidity changes. Cloths with a variety of constructions are being examined in the laboratory to identify these causes more precisely.

(*b*) *Electrical Properties*.—The electrical resistance of wool decreases by a factor of 10,000,000 as the fibre changes from the dry to the wet state, and this explains why wool rarely causes difficulties in processing due to static electricity, and why wool clothing does not develop electrical charges which cause discomfort or attract dirt.

Measurements of the electrical resistance of a wool fibre while being stretched shows two effects. Firstly, an increase occurs in excess of that due to the fibre becoming longer and thinner and then, after stretching, a decrease occurs due to the entry of water into the structure.

(*c*) *Regain in Wool*.—Studies have continued on the exchange of water between a mass of wool and the air passing through it. Calculations based on the measured sorption of water by single wool fibres have led to the construction of a small drier for loose wool to test out some new possibilities in the field of wool drying. They have also provided the data for the construction of an apparatus for the rapid drying and weighing of samples for certificate purposes. This "C.S.I.R.O. Regain Apparatus" shows substantially better performance than commercially available regain testers. It is capable of determining the regain of a 100 g. sample of wool to an accuracy of 0.01 per cent. in 7 min. and will be of special value to the newly formed Australian Wool Testing Authority. Measurements have been made of the moisture content of samples taken from bales of scoured and carbonized wool using the coring method to determine the variation in moisture content within bales and between bales. This information will also assist the Authority to develop wool sampling methods to suit Australian conditions.

The method of estimating the regain of wool by measuring its electrical capacity at two different frequencies is complicated by the presence of electrolytes in the wool. Apparatus is being constructed to examine if the method is applicable to the continuous measurement of the regain of a backwash sliver.

The sorption of water by single wool fibres using the vibrating string technique is being investigated further over a range of temperatures, notably between 100 and 105° C. Fibres dried at these high temperatures take an unexpectedly long time to absorb moisture from the air.

To determine what drying procedures must be used in order to obtain correct values for the dry weight of wool, a vacuum apparatus has been constructed in which the drying and wetting operations can be carried out under accurately controlled conditions of temperature and water vapour pressure. The samples are suspended on quartz springs and the weight changes are followed by observation with a cathetometer. It has been shown that errors exceeding 1 per cent. of regain can be introduced by using incorrect drying procedures.

8. STRUCTURE OF THE WOOL FIBRE.

(Wool Textile Research Laboratories.)

(*a*) *Direct Examination of the Fibre*.—With the aid of a new method of embedding wool fibres, using epoxy resin, sections can now be cut sufficiently thin for examination under the electron microscope. Formerly it had been necessary to confine attention to the softer wool roots which are readily sectioned when embedded in methacrylate resin. Fully hardened Merino fibres, which have been partly extracted and then fixed in osmium tetroxide, reveal marked differences between the ortho and para segments. The former show fibrils within the cortical cells separated by regions of lower protein density where chemicals attacking the ortho segment would be expected to penetrate. Cells of the para segment, on the contrary, are clearly outlined by the cell membranes, but apart from spaces formerly occupied by nuclei, they show no internal structure. Microfibrils have been identified in sections of fibres after reduction with thioglycollate at pH 5 and fixing in osmium tetroxide, the metal being deposited in the intermicrofibrillar matrix. Intensification of certain spots in the X-ray diffraction photograph of the same material, corresponding to the deposition of metal between the microfibrils, represents an important correlation between these two techniques. Intensification of other spots in both the equatorial X-ray pattern and in the meridian, corresponding to repeats of pattern in the direction of the fibre axis, has been obtained by treatment with mercuric acetate and with lead acetate following reduction.

Measurement of the infra-red absorption spectra has provided information about the orientation, configuration, and accessibility of wool. Treatment of wool with deuterium oxide eliminated the absorption due to amide groups in the infra-red spectrum, and this, together with other evidence, may mean that the amide groups in the crystalline regions of wool are accessible to water.

From examination under the microscope of short lengths of wool fibre while heating them in lithium bromide solution, supercontraction proceeds in two stages. The rubber-like properties of the fibres while immersed in the supercontracting medium permits the application of elastomeric theory which suggests that cystine may provide the restraining cross-links. Ultraviolet irradiation influences both the supercontraction and the setting of wool fibres, and the wavelengths concerned are such as would be expected to affect bonds at or near the tryosine residues.

Supercontraction of wool fibres when heated in phenol solutions is due chiefly to phenolate ions if the solution is alkaline and to unionized phenol if the solution is acid.

Electron microscopy of the inner root sheath of hair vibrissae has revealed a cellular structure with spaces between the cells through which metabolites could pass to the growing root. Analysis of the fibrous protein of the inner root sheath has shown the presence of a significant quantity of citrulline, and amino acid not previously found in protein combination. The same amino acid has been detected also in the wool follicle.

(*b*) *Examination of Extracted Proteins*.—Following the isolation of a protein fraction from wool by extraction with thioglycollate, its conversion to SCMK2, and further purification with zinc salts, a second protein fraction has now been obtained. Protein remaining in the extract after precipitation of this second wool protein has a high sulphur content and may originate in the matrix between the microfibrils. Several methods have been found for disaggregating SCMK2 and the wool protein derivative, α-keratose.

(*c*) *Estimation of Amino Acids.*—The ion-exchange chromatographic method of estimating amino acids has now been made fully automatic, the extinction coefficients of the colours produced in successive fractions with ninhydrin being recorded on graph paper.

The estimation of cystine and cysteine in wool has been greatly improved through the adoption of polarographic methods. These acids may be estimated in 10-100 mg. samples of wool by the addition of excess mercuric chloride to an acid hydrolysate and by determination of the excess by polarography. Amounts between 0.15 and 0.10 mg., that is, corresponding to single Merino fibres or portions cut from coarse wool fibres, are analysed by determining their effect on the catalytic cobalt wave. Most important, however, has been the application of organic mercurials, for example, "Neohydrin", for estimating cystine and cysteine in intact wool by using urea to swell the fibre. Cystine methods involving hydrolysis yield values up to 4 per cent. too high if applied to wool containing thioether groups which have been oxidized.

9. WOOL PROTEIN CHEMISTRY.

(Wool Textile Research Laboratories.)

(*a*) *Studies on the Wool Fibre.*—The disulphide bonds are the most reactive groups in wool, and conversion of each disulphide bond into two *S*-sulphocysteine groups by reaction with a solution containing ammoniacal cupric ions and sodium sulphite, as mentioned previously, has now been confirmed and extended. Reaction of the *S*-sulphocysteine with cyanide yields the corresponding thiocyano derivative, and reaction with another thiol yields mixed disulphide. The thiocyanoproteins can also be obtained by reaction of reduced wool with cyanogen chloride. Studies are proceeding on the reaction of wool with reagents such as formaldehyde, with various reducing agents, including bisulphite, and with more specialized reagents with which it is hoped to modify specific chemical features of the molecules.

If the more readily split disulphide bonds in wool, known as the A + B fraction, are replaced by stronger cross-links, and the less readily split bonds, known as the C + D fraction, are then ruptured, the Hookean region of the stress-strain curve of the fibre is shown to be eliminated. Stretching fibres while immersed in thioglycollate solution at pH 5 has been shown to increase the extent of reduction of the disulphide bonds.

(*b*) *Studies with Model Compounds.*—Research on cystine-containing peptides has led to the synthesis of a wide range of intermediate compounds, including two heptapeptides containing S-benzylcysteine. A peptide containing one cystine and five glycine residues, in which the disulphide bond and the peptide chain form a closed ring, has been prepared.

10. PROTEIN STRUCTURE.

(Division of Industrial Chemistry.)

Work on the structure analysis of amino acids is proceeding and current studies have been extended to the peptides. These are chosen either because they occur naturally, or because they have particular significance in the structural pattern of specific proteins.

L-Leucylglycylglycylglycine has been synthesized by the carbobenzoxy method. The coupling of two of these units, which occurs with good efficiency, has yielded the carbobenzoxy octapeptide. X-ray structure analysis of the basic unit, LGGG, is well advanced.

The sequence -L-prolyl-L-hydroxyprolyl- has been found to be significant in the structure of collagen, and a selected derivative, tosyl-prolyl-hydroxyproline has been analysed.

The final stages of the analysis of aspartic acid hydrochloride revealed some weaknesses in previous calculations of X-ray atom scattering curves, and further calculations based on a more refined electron distribution have been made. The disposition of hydrogen atoms in this compound has been established by a more complete treatment of the data.

Further study of the iodoacetate of evolidine, an interesting natural heptapeptide, revealed that this derivative decomposed in the X-ray beam, even at low temperatures, and a search is being made for a more suitable derivative. Other peptide crystals are being examined to determine their suitability for more detailed investigation.

The power of the X-ray method is closely allied to the range and quality of the experimental data. A high-power (6-7 kW) X-ray generator, permitting a tenfold reduction of exposure times, is now in regular use. Valuable high-angle data can be obtained when combined with the low-temperature adapter for the Weissenberg goniometer.

These improvements in technique provide experimental data which allow the application of modification functions with greater confidence; this has permitted a more rigorous test of "image-seeking" techniques of structure analysis. Thus, it was possible to show, for tosyl-prolyl-hydroxyproline, that the sulphur atom in the presence of 26 other atoms (C, N, and O) was of sufficient power to initiate the analysis. However, it was also found that with the addition of further atoms to the "image-seeking" function, the situation does not improve as expected but tends to deteriorate. This limitation in "image-seeking" techniques is being studied. The selection of more suitable functions will probably require accurate knowledge of scattering curves, particularly for the principal "marker" atoms. Of such atoms, Cl, S, and P are all of importance in biological systems and the curves available in the literature are considerably in error. To eliminate these errors, first noted in aspartic acid hydrochloride, new calculations have been made.

11. GENERAL PROTEIN INVESTIGATIONS.

(Wool Textile Research Laboratories.)

To explain the effect of some salts on the supercontraction of wool fibres, experiments have been made on the effect of various ions on the thermal contraction of another fibrous protein, collagen. Unlike wool proteins, changes in the structure of collagen are not complicated by the presence of disulphide bonds, since it contains no cystine. Anions appear to affect the contraction of collagen partly through being absorbed and thus affecting the net charge on the protein, and partly through the water carried into the collagen by the associated cations.

Bovine serum albumin and other proteins have been used to demonstrate that amino acid hydrochlorides are unsuitable as electrophoresis buffers.

12. BIOLOGICAL DEGRADATION OF CELLULOSE.

(Wool Textile Research Laboratories.)

In an initial survey of the digestibility of pasture plants samples were prepared of crude fibre and α-cellulose from *Phalaris*, Wimmera ryegrass, and subterranean clover at different stages of growth, and these were used as substrates for growth of the fungi *Stachybotrys atra* and *Lenzites trabea* and for the bacterium *Cellulomonas biazotea*. Results were variable and no differences were detected between samples from the same plant at different stages of maturity. Differences were observed, however, between different species of plant.

XVII. INDUSTRIAL CHEMISTRY.

1. General.

Although certain supplies of raw and processed materials must always be imported to fulfil special manufacturing requirements, it is nevertheless essential for Australia to develop local raw materials wherever this is economically possible.

The Division of Industrial Chemistry represents the major concentration of chemical research within the Organization, although much chemical work is undertaken in other Divisions and Sections.

This Division was formed to promote greater technical efficiency in established industries; to stimulate the establishment of new industries; to encourage the use of raw materials of Australian origin; to seek substitutes for imported materials; to find uses for by-products not utilized; and to study national problems to which the Division can contribute by virtue of its experience in other fields. This Chapter describes the work of the Division.

The Division's study of the constituents of wool wax and ways of utilizing them or their derivatives is described in Chapter XVI., Section 4. The Division is also studying the structure of proteins in relation to wool (see Chapter XVI., Section 10). The Division's work on the utilization of brown coal is described in Chapter XIX., Section 5.

Divison of Industrial Chemistry.—Several companies have placed their confidence in this Division by sponsoring pilot-plant work.

An example of this type of co-operation with industry is the development of the Weiss-Swinton jigged-bed process for continuous ion exchange. It was recently announced that a single full-scale unit will be installed at Rum Jungle for final tests on the recovery of uranium from Dyson's ore, and so bring to a final stage the development and application of this new metallurgical technique. The extensive work on the development of this process has been made possible only by the continuous and generous support of the Australian Atomic Energy Commission, which financed the first pilot plant, and by the grants received from the Rio Tinto Company Limited and Territory Enterprises Proprietary Limited for tests on the Mary Kathleen and Dyson's ore respectively. It is pleasing to acknowledge the important part played in the engineering development of the process by the Organization's licensees of the process for uranium recovery, the Permutit Company.

The Division has recently completed another major project with support from industry. In 1953, Mount Morgan Limited and Mount Lyell Mining and Railway Company Limited arranged with the Division to conduct an investigation of the fluid bed roasting of copper concentrates and the subsequent leaching and electrowinning of copper. These companies were later joined by Mount Isa Mines Limited and Peko Mines N.L. in sponsoring the investigation. This work has now been brought to a successful conclusion (see Section 2 (*a*) of this Chapter). Over the period of the investigation, the companies have contributed a total of £40,300.

The Cement and Concrete Association, which has made an annual grant for the past sixteen years as a contribution to the Division's research on cement, has this year increased its grant to £5,000. Work on the sintering of brown coal ash is being supported by the State Electricity Commission of Victoria, the Gas and Fuel Corporation of Victoria, and Australian Paper Manufacturers Limited.

A group of Australian companies is sponsoring an assessment of a process for the production of rutile from ilmenite.

In January, 1958, Dr. H. R. C. Pratt, formerly of the Chemical Engineering Division of the Atomic Energy Research Establishment, Harwell, joined the Division as leader of the Chemical Engineering Section.

2. Mineral Utilization.

(Division of Industrial Chemistry.)

This Section is mainly concerned with the techniques of extractive metallurgy. The recovery of many of the less common elements from their ores are studied concurrently with the extraction of well-known metals such as copper. Projects in both classes of work have been sponsored and financed by Australian industry. The emphasis on hydrometallurgical processes, including pressure digestion techniques, which was maintained throughout much of the programme, is in sharp contrast to the modern version of pyrometallurgical purification applied to thorium carbide and the derived metal as described herein. Fundamental studies on various metal and mineral derivatives which have been undertaken concurrently with the applied research fall into two classes: those which are incidental to the main object of the research, and those which have as their object the assessment of mineral derivatives which may eventually lead to new industrial utilization.

(*a*) *Hydrometallurgy of Copper.*—The investigation which has occupied the attention of a small group for the past four years has now been completed. The companies which originally requested the Division's collaboration, Mount Morgan Limited and Mount Lyell Mining and Railway Company Limited, were later joined by the two remaining major copper producers of Australia, Mount Isa Mines Limited and Peko Mines N.L., while the Copper Producers' Association supplied the liaison between these companies and the Organization. This type of collaboration, in which funds were supplied by private interests for an investigation of a specific process, is a departure from the previous practice of the Division.

The investigation concerned the possibility of replacing conventional smelting and refining by leaching and electrolysis, after an initial roast in a fluidizing bed reactor. The Chemical Engineering Section undertook the investigation of the roasting techniques, and the leaching of the calcines produced in the roaster and the winning of copper metal by electrolysis from the liquor were then taken up by the Minerals Utilization Section.

It became apparent that there was not one hydrometallurgical problem but several related problems, and the objectives of the project became:—

(i) To recover as much copper from the calcine as possible. As some existing methods are very efficient in this respect a high target of 97 per cent. recovery was aimed at.

(ii) To recover as much gold from the calcine as possible, as three of the four mines at present derive income from gold.

(iii) To deposit the copper in a form sufficiently pure for direct melting and casting into marketable shapes. The specifications of the electrical industry for ductility and conductivity required that many impurities do not exceed a few parts per million.

(iv) To deposit the copper in a massive coherent form which can be readily transported and melted, and not as a powder or sponge.

(v) To recover the copper with the minimum consumption of power. The power for electrolysis may amount to two-thirds of the total running costs of the whole roast-leach plant, labour included.

(vi) To produce as little waste acid as possible, thus obviating the need to neutralize large quantities of acid with limestone to avoid pollution of adjacent water supplies. Where the process has been suggested overseas, excess acid has been in demand and this simple difference is responsible for many unique aspects of the investigation.

(vii) To integrate the various parts of the process into a workable whole. Some of the above aims were antagonistic, and a change at any stage of the process required modifications in the others.

These problems demanded a diversity of knowledge and skills and collaboration was frequently sought both inside the Organization and elsewhere. A senior member of the group made a sponsored visit to the large copper leach plants of central Africa with the object of comparing recommended procedures with those practised elsewhere.

Experiments were begun on a laboratory scale but were finally taken to semi-pilot-plant scale for the leaching, purification, and electrolysis processes. The need for rapid analytical control led to the development of new procedures in polarography and spectrophotometry, for eight different elements of significance in the process. Spectrographic analyses were conducted by the South Australian Mines Department.

A study of the first objective showed that careful control of roasting was the key to success and that inadequacies of roasting could not be made good by simple modifications of leaching technique. The best roasting techniques achieved a 97 per cent. recovery for calcines from all mines. The second object was achieved by the Organization's Ore-dressing Laboratories at Melbourne University, which recovered, by cyanidation, more than 90 per cent. of the gold from the calcines of the two mines so far studied. The economics of cyanidation were found to depend on the method of roasting and leaching. Unexpected difficulties arose in the preparation of pure copper, leading to the discovery of molybdenum as a new addition to the metals whose presence is deleterious to copper. The occurrence of very small quantities of molybdenum in the concentrate, unnoticed when treated by the conventional process, produced metallic copper too brittle to be handled. It also caused arsenic to be concentrated in the copper. Several methods of preventing the deposition of molybdenum (and with it arsenic) were found, the simplest being by the addition of small amounts of chloride to the electrolyte. The Industrial Research Section, Metallurgy Department, University of Melbourne, undertook the melting and casting of the pilot-plant cathodes, wiredrawing, and metallographic examination. It was shown that wire of conductivity exceeding the usual standard could be produced from the products of all four mines. This being the final criterion of the technical feasibility of the overall process from roasting to wire-drawing, costs remained as the major consideration. Power costs vary widely at the four mine sites. Power consumption, depending primarily on the amount of iron in the electrolyte, can be reduced by control in the leaching and roasting stages, though more effectively by solution purification. Conventional limestone precipitation was compared with hydrolysis developed in the Section's general studies on pressure leaching. The same roasting control has enabled less acid and less sponge copper to be produced, so that the next three aims proved to be inseparable. Simple mathematical expressions have been found relating the main running costs (power and limestone) to the conditions of roasting and leaching. These expressions form a basis for deciding which of three or four possible flow sheets or processes would be the most suitable for the conditions prevailing at each mine, e.g. whether the capital costs in setting up a purification section would be warranted by the savings in power.

The extraction of bismuth, lead, and cobalt from calcines of one of the concentrates has also been investigated and promising methods found for recovering about 80 per cent. of each metal in the form of a concentrate. The possibility of increased use for the valuable metals bismuth and cobalt in nuclear reactors and high temperature alloys, respectively, lends added weight to this study. Fundamental investigations have been conducted on methods of analysis, heterogeneous kinetics, and the mechanism of electrode processs.

(*b*) *Uranium Extraction.*—An investigation has been commenced into the possibility of selectively extracting uranium from monazite sands. Under existing circumstances, it is not economic to decompose monazite completely for uranium recovery, as an adequate market does not yet exist for the rare earths and thorium simultaneously produced. Current work is concerned with the promising effects achieved by sintering monazite with appropriate salts, followed by leaching with dilute acid. In this way, very little monazite, but a substantial portion of uranium, is dissolved.

A simple but effective precipitation method has been devised for the removal of phosphate from uranium-rich eluates at Rum Jungle. Studies on the removal of phosphate from leach liquors during solvent extraction have been completed.

Analytical services and personnel have been provided in support of the jigged-bed process for recovery of uranium from leach liquors. Studies have also been made on the possible additional leaching of uranium from leach residues during thickening operations. Co-operation with the Australian Atomic Energy Commission and Territory Enterprises Proprietary Limited has been continued, and the results of this work have been given restricted publication in the form of seven technical notes.

(*c*) *Chemistry of Zirconium and Hafnium.*—In the period under review the National Distillers and Chemical Corporation of the United States of America completed the payments for their purchase of the overseas rights to use the process patented by the Organization for the separation of hafnium from zirconium. Work is continuing on the chemistry of zirconium.

(*d*) *Chemistry of Thorium.*—A process for obtaining thorium of high purity has been developed. Thorium oxide used as a source material is heated to a high temperature with carbon to form thorium carbide. A small amount of iodine is added to an evacuated vessel containing the powdered or pelleted thorium carbide heated to a temperature below red heat. The volatile thorium iodide produced by reaction of thorium carbide with iodine acts as a carrier to convey thorium to another part of the vessel containing a filament heated electrically to white heat. Thorium metal deposits on the filament, gradually building up a metal rod, and iodine liberated by thermal decomposition of the iodide is made available for further reaction with thorium carbide.

The carbon, oxygen, and nitrogen contents of the product are as low as, or lower than, those in the best material obtained from a metal feed. A study of the relevant variables has shown that the rate of growth of the product compares favourably with that obtained with thorium metal feed materials. Thus a simpler and cheaper method for making pure thorium has been made available, as it is no longer necessary to use expensive raw materials in the form of thorium metal of relatively low purity. Such costly starting materials have hitherto relegated the original Van Arkel-de Boer process to the role of a refining process only.

A feature of the carbide-iodide process is the high degree of purification attainable. This has been investigated experimentally by use of radioactive tracers, and theoretically by calculation of appropriate thermodynamic functions for virtually all the elements. This has been done for each stage of the process. For each of these stages a useful correlation has been obtained between experimental and calculated results, and prediction of the overall behaviour of most impurity elements can now be made with some confidence.

Very considerable purification occurs during the carbide formation stage when low concentrations of some 60 elements volatilize at the high temperature required to convert thorium oxide to thorium carbide. The remaining impurity elements are separated at one or other of the four principal stages of the metal deposition process. Thus some impurities may be separated from the product metal because the iodide of the impurity metal is unstable in the presence of thorium carbide, or is of too low a vapour pressure to transfer the impurity to the filament. Other impurities may be separated because the iodide of the impurity metal is too stable to be decomposed by the heated thorium filament or because the impurity metal concerned is too voltatile to remain on the filament. Only uranium, zirconium, hafnium, and possibly protoactinium, transfer substantially to the product metal.

The carbide-iodide process also has other applications. Thus thorium metal or ceramic materials containing thorium which have been irradiated in an atomic reactor can be decontaminated from fission products. Both the thermal decontamination occurring during the carbide formation stage and the greater degree of decontamination occurring at the metal growing stage may have useful applications, while the decontamination attainable in the overall process exceeds by several orders of magnitude that obtained in most current pyrometallurgical decontamination procedures.

(*e*) *Germanium Extraction.*—Examination was continued of hydrometallurgical and pyrometallurgical extraction techniques for the recovery of germanium from certain coal-fired power-station flue dusts. Improvements made to a process based on dilute acid leaching resulted in an increase in extraction yield to 80 per cent.; yields of this order were also noted when using aqueous alkaline systems. To evaluate these processes and to study the reactions associated with release of germanium from the complex silicate mixtures, data have been obtained on the simultaneous transfer to solution of SiO_2, Al, Ti, and PO_4. Satisfactory recovery from leach solutions has been achieved by using precipitation and ion-exchange techniques.

(*f*) *Chemistry of Graphite.*—Work was concluded to elucidate fundamental aspects of the formation of molecular compounds of graphite and to add to this class of compound a large number of new examples.

Interest in the corrosion resistance of graphite used as a moderating material in certain types of atomic reactors has prompted investigation of the reactivity of graphite towards several materials such as metal coolants which may also be present. The possibility is being studied of taking advantage of the high selectivity shown by graphite in its intercalation reactions to effect separation of fission products during reprocessing of spent atomic fuel elements.

The possibility has been indicated of varying the electrical and thermal properties of graphite to suit specific purposes by the intercalation of various materials in the graphite lattice. Entirely new anisotropic compounds with possible uses as electrical semiconductors may be produced by this technique.

(*g*) *Chemistry of Lithium.*—Investigation was completed of the various methods of extracting lithium salts from spodumene. This project, sponsored by the Western Mining Corporation, was an assessment of the various factors involved in processing hand-picked spodumene, containing 4.8 per cent. lithium oxide, by such methods as roasting with lime, sintering with lime and gypsum, or extraction by the sulphuric acid, ion-exchange procedure. Although each method gave satisfactory yields of technical-grade lithium derivatives, the sulphuric acid, ion-exchange process offered the most advantages.

The conversion of α-spodumene to the β-modification by heating the mineral for a few minutes at 1,100° C. is a necessary preliminary stage of the acid process and serves well to illustrate the scope for increasing the chemical reactivity of various minerals by alteration of the crystal structure. This has been investigated from several aspects apart altogether from lithium minerals. Various natural decomposition products of silicate minerals were studied with a view to correlating the general effects of weathering with analogous changes effected more rapidly under laboratory conditions

(*h*) *Transition Group Sulphides, &c.*—Work on the synthetic chalcogenides of titanium, zirconium, hafnium, and thorium was completed, and the results, comprising X-ray and structural data, chemical properties, electrical properties, and lubrication data, were submitted for publication. The chalcogenides of niobium and tantalum were also prepared and investigated by X-ray techniques.

(*i*) *Chemical Crystallography.*—Much of the emphasis in this subject in the past has concerned the insertion of large cations into transition metal oxides with a view to the formation of semiconducting " bronzes " which are potentially useful industrially. The complementary problem is the substitution of smaller ions of different valency for the host cations with the consequent creation of vacant sites which, if in a sufficiently large concentration, could modify the properties of the host oxide. With the collaboration of the Cement and Ceramics Section, a start has been made upon the system $CaO\text{-}TiO_2$ with a view to improving the hydration resistance of lime, a potentially valuable refractory material.

(*j*) *Pressure Hydrometallurgy.*—Further kinetic studies have been made on the decomposition of sulphide minerals in the presence of water and oxygen. Covellite and pyrrhotite have been added to the list of minerals mentioned in the previous report. Reactor design has been further improved by incorporating devices for the control and measurement of pH during operation and for the introduction of samples at a high temperature by means of an oxygen blast. A new and larger reactor has been built for studying oxygen transfer rates and to allow recirculation of oxygen during operation. Applied studies have also been made on the recovery of valuable base metals from pyritic cinder, using oxygen and water as the sole reagents.

In the non-sulphide field, work is in progress on the hydrolysis of iron and aluminium sulphate solutions at temperatures up to 200° C. Under non-equilibrium (i.e. short time) conditions, the compositions or solubilities of the hydrolysis products may vary from those reported for equilibrium conditions, and various interesting applications of the new results have been envisaged. Iron contamination in copper calcine liquors can be reduced to a surprisingly low level of autoclaving for a brief period at 200° C. The pressure technique has also been used to accelerate the decomposition of several non-sulphide minerals and ores, simultaneously taking advantage of the hydrolytic effects to obtain a purer product. With phosphatic uranium ores, for instance, practically all the phosphate is removed from the leach liquors as insoluble ferric phosphate during digestion.

3. CEMENT AND CERAMICS.

(Division of Industrial Chemistry.)

(*a*) *Cements and Concretes.*—(i) *Analytical Methods.*—Members of the Cement and Concrete Association of Australia have expressed a desire for an analytical schedule sufficiently rapid and accurate to be used as a control on all the main components of both raw materials and products in cement plants. Suitable methods are being developed, based largely on the use of the absorption spectrophotometer.

A satisfactory degree of precision of the six main oxide components of cements should be attainable in an analysis taking only 1½ hr.

(ii) *Cement Characteristics.*—The behaviour of mortars made from cements of higher sulphate content than normal is being examined, at the instigation of Australian manufacturers. It has been shown that the strength of such mortars may be adversely affected by an increase in sulphate-bearing components.

Fundamental studies using various Australian cements have shown that for a given cement and a fixed water-cement ratio, there is a linear relationship between strength development and the extent of hydration. The relation is linear over a range of water-cement ratios from 0.16 to 0.80. Temperature variations and the presence of retarding agents appear to be purely kinetic factors, and do not affect the basic dependence of strength on the proportion of cement hydrated.

It has been found that Australian cements often show slight premature stiffening in the mixing stage. This may, on occasion, increase the water requirement for normal consistency, and hence lead to a lower strength than might otherwise be obtainable from such cements. A detailed X-ray examination of these cements has suggested that decomposition of the gypsum component may be a possible cause of the stiffening phenomenon.

(iii) *Concretes.*—Further additives and treatments have been studied to improve the workability and durability of concretes. The plastic properties of concrete mixes can now be varied over a wide range by suitable additions of flocculants, deflocculants, and air-entraining agents. Extended laboratory trials have shown that concretes can be made completely resistant to sulphate attack.

An examination of the adhesion developed between hardening concrete and different liquid and solid substances has shown that orthodox form oils and linings can be replaced by much more efficient materials. Materials of grease-like consistency are better than oils, whilst certain plastics have excellent properties as linings.

In studying the strength components of concrete it has been shown that bond strengths between cement paste and the surfaces of different rock types exhibit appreciable variation. Laboratory determinations of such bond strengths can be correlated to some extent with the strength of concretes as determined in the field.

In view of the variation in concrete strength with different rock types, a collaborative project with Australian cement manufacturers has been instituted, to determine whether more consistent results are possible in concrete testing when a standard aggregate is used, than when the choice of aggregate is left to the individual testing authority.

(*b*) *Refractories.*—(i) *Cement Kilns.*—The behaviour of rotary kiln linings has been investigated further, with particular reference to the effects of kiln distortion. Measurements have been made on operating kilns in several cement plants, and some instances of appreciable flexing of the shells have been encountered. Corrective measures have been recommended and are being adopted.

(ii) *Silica Bricks.*—As low porosity is an important requirement in silica refractories, particularly those used in steel production, the factors which control this property have been examined. Notable reductions in porosity can be made when special raw-material gradings are used in conjunction with small additions of boundary-layer lubricants in the pressing stage of fabrication.

Further work on the embrittlement of silica bricks in reducing atmospheres has not given a clear picture of the mechanism involved, although the effect has been demonstrated with further samples of refractories from overseas sources.

(iii) *Cermets and Oxide Refractories.*—Experimental turbine blade shapes have been fabricated from a modified alumina-chromium cermet. A titanium carbide-nickel alloy cermet has been used in the construction of dies for the application of hot-pressing techniques to reactive raw materials. Hot-pressed and sintered thoria bodies have been fabricated for the Australian Atomic Energy Commission.

Composite ceramics of high electrical conductivity have been prepared for evaluation as heating elements. The metallic characteristics of these composites are due to the presence of molybdenum disilicide.

The projects on the slip-casting and sintering of magnesia and lime has been completed. Studies aimed at increasing the stabilization of lime have shown that some success can be attained through the addition of elements of higher valency to the oxide system.

(iv) *Brown Coal Ash.*—This work is reported on in Chapter XIX., Section 5.

(*c*) *Ceramics.*—(i) *Clay Investigations.*—Samples of kaolins, plastic clays, bentonites, and related raw materials submitted from deposits in all States were examined and assessed for potential utility in various industries. Detailed investigations of the Egerton and Heyfield deposits were made.

Further studies on the nature and behaviour of halloysites and vermiculites were made. By analogy with carbon-vermiculite complexes, a method of preparing carbon-montmorillonite complexes was developed, and sufficient material of this type is now available for evaluation as a potential pigment. It is also an efficient adsorbent, and should have useful molecular sieve properties.

(ii) *Whiteware.*—Several problems involving experimental and advisory work were submitted by industry, including the development of a wall-tile body resistant to moisture expansion, the cracking of drain tile during firing, clay preparation difficulties in the compounding of tableware body, the improvement of artware body colours, and the production of lead silicate frits.

(iii) *Adelaide Laboratory.*—With the renewed support of the South Australian Government for a period of two years, several reports on raw materials have been issued, and special investigations are in progress on the suitability of shales for brick production, and on the characteristics of clays used in roofing tile manufacture.

4. Foundry Sands Section.

(Division of Industrial Chemistry.)

A laboratory, located in the Metallurgy Department of the Royal Melbourne Technical College, is equipped for the study of foundry problems with special reference to moulding sands, and for assistance to industry. A catalogue of Australian moulding sand deposits is maintained, and new sources are continually being investigated to assess their usefulness in the foundry industry. The need for improved surface finish in castings has stimulated study of the production of fine sands as base materials.

A study of the formation of " buckle and scab " defects in castings has shown that these are due to the very rapid expansion of the thin crust of sand adjacent to the molten metal and not to the expansion of the whole mass of sand. The equipment is being designed for routine control tests in foundries.

The Section is studying the effect of adding small quantities of various salts to clays for synthetic sands. Such additions cause a significant change in the strength properties of the sands, especially on drying. It has been shown that the effect is not due to an alteration in the hydrogen ion concentration, as other workers have maintained.

One of the Section's officers who had worked at the Tin Research Institute in England on the production of steel-backed aluminium-tin bearings is now assisting an Australian automotive company in the production of such bearings. A method has been developed of casting duplex bearing alloys.

To develop a nearby source of sands for foundries at Geelong, methods are being investigated for separating finely divided shell from the sand in deposits on the Bellarine Peninsula.

5. Physical Chemistry.

(Division of Industrial Chemistry.)

(*a*) *Conservation of Water.*—The experiment at Stephen's Creek Reservoir, Broken Hill, using cetyl alcohol dissolved in a solvent, was continued until September, 1957. Between December, 1956, and September, 1957, evaporation was reduced overall by about 32 per cent., there being a noticeable trend towards reduced effectiveness of the film during the winter months. As a result of this experiment, some features of the process which require improvement became apparent. In particular, spreading of the film from the floating drops of cetyl alcohol solution was often retarded by film already present. A new type of dispenser, capable of minimizing this fault, is being developed.

It has been found that some commercial samples of cetyl alcohol diminish in spreading power when left floating on water. The change was traced to a phase transition which occurs when the cetyl alcohol reaches a temperature which depends on impurities present in the cetyl alcohol. The transformed material does not spread as well as the original material.

The small-scale process for reducing evaporation, which uses floating containers filled with beaded cetyl alcohol, is at present in wide use. Some have found difficulties with the process; a few disappointing results, probably due to faults in the cetyl alcohol, have been reported, but most troubles have followed heavy clogging of the containers. Advice on these matters has been given, and new methods are being investigated of storing solid cetyl alcohol on a water surface.

(*b*) *An Ion-exchange Process for the Recovery of Uranium from Ore Slurries.*—Research continued on the jigged-bed process for the recovery of uranium by a continuous ion-exchange process without filtration of the leaching liquors. In conjunction with Territory Enterprises Proprietary Limited, a pilot plant was operated successfully on an ore not readily amenable to conventional treatment. The jigged-bed process appears to be cheaper to operate than the conventional process irrespective of whether the ore, after leaching, is difficult or easy to filter.

The mechanical development of a commercial unit having a diameter of four feet was completed by the Permutit Company Limited, of London, which has been granted licences to use this group of patents, and this unit will be installed in the near future for further testing at Rum Jungle, Northern Territory.

(*c*) *Chemistry of Tar from Lurgi Gasification Plant.*—The investigation of the constituents of tar from the Lurgi gasification plant of the Gas and Fuel Corporation of Victoria was continued. The tar was separated into several fractions boiling between 40 and 400° C. and then further separated into phenols, bases, and hydrocarbons.

The lower boiling mixtures of hydrocarbon were separated further by adsorption into fractions containing paraffins, olefins, and aromatics from which the components are being prepared by fractional distillation. Gas chromatography is being used to identify and estimate the individual hydrocarbons present in the tar.

Vapour-phase chromatography has also been used by officers of the Organic Chemistry Section to analyse the mixture of phenols present in the tars. A crude tar acid mixture can now be examined. First, a large vapour-phase chromatographic unit resolves the crude phenols into several fractions of a few grams and these are then resolved on the analytical column. The two columns employ different stationary phases. The combined process gives a quantitative analysis for most of the lower-boiling phenols with a speed not possible with normal fractional distillation. The extent to which the method is applicable to higher phenols has yet to be determined.

(*d*) *Properties of Liquids.*—The properties of liquid mixtures determine the ease with which many separations may be effected in industrial distillations. A new formal approach to the theory of mixtures has unified the various approximate theories and indicated how more accurate information may be obtained. Numerical calculations were made for this generalized theory and suitable computational methods were developed for the solution of bilinear simultaneous equations arising in most theories of associated liquids.

Difficulties in the determination of the heats of mixing of two liquids at elevated temperatures were overcome in a new cell in which a membrane separating the liquids is ruptured. Measurements were made on mixtures containing acetone, ethanol, nitromethane, and acetonitrile.

(*e*) *Chemical Effects of High Pressure.*—Study is continuing of the effects of pressure on the rates of equilibria of important reactions in solutions as these will allow prediction of the types of reaction favoured by pressure. In the range 1-10,000 atmospheres, a detailed study has been made of the errors introduced by the unavoidable heating during compression. The principal development, however, is the introduction of a new technique for producing extreme pressures for short periods. When an explosive is detonated in contact with a solid or a liquid, a strong shock wave is driven into the material. The shock causes a sudden increase both in the temperature and pressure, and in a typical solid these may reach 1,500° K. and 250,000 atmospheres respectively for a few millionths of a second. Under these conditions a typical non-metal such as sulphur develops metallic properties, and water becomes highly ionized. Both effects were expected on theoretical grounds.

(*f*) *The Chemistry of Carbon.*—Earlier work emphasized the unique character of activated carbon when considered as an organic polymer. Unlike other organic polymers it is an excellent conductor of electricity, it is abnormally hard, and it possesses unique ion- and electron-exchange characteristics. These aspects are being studied further.

(*g*) *Metal Organic Complexes and Enzymes.*—Some metal-organic complexes behave like the enzymes that are important in biological processes. The mechanisms were investigated of the decomposition of water by cobaltocyanides to give hydrogen, the evolution of oxygen from hydrogen peroxide by the enzyme catalase, and the uptake of oxygen by the enzyme cytochrome oxidase.

That an aqueous solution of potassium cobalticyanide, when illuminated by light of wavelengths up to 4,900Å, produces a highly reactive complex which is capable of decomposing water with liberation of hydrogen gas suggests that solar energy might be used to generate a fuel, hydrogen, from water.

(*h*) *Nucleation to Form Ice.*—The action of silver iodide in the formation of snow in—and hence rain from—a cloud is still incompletely understood. The effects of silver iodide on supercooled clouds and on supercooled water droplets have been compared with the growth of ice from the vapour directly on to silver iodide particles resting on a glass substrate. All three methods give substantially the same results, except the experiments on clouds appear to be particularly sensitive to accidental contamination and therefore require stringent precautions if the results are to apply generally.

The activity of silver iodide as an ice nucleus varies according to the manner in which the sample is prepared, the most active form being that prepared by treating a silver smoke with iodine vapour.

It is known that exposure of silver iodide to sufficient light renders the material useless as a seedling agent; this failure is common to all samples yet prepared. Special preparations containing small amounts of lead or cadmium are less affected by light, but this advantage has invariably been offset by a reduction in intrinsic nucleation efficiency.

Of special interest is the discovery that ion relatively free from oxide has a nucleation efficiency equal to that of silver iodide.

(*i*) *Fire Research.*—Research on the fighting of bushfires has continued in both the laboratory and the field, although the short duration of most bushfires visited limited field programmes. Nevertheless, data gained have been used in the design of a model fire to simulate bushfire conditions in the laboratory.

A cream containing aluminium flake which insulates the skin has been produced for protection of fire fighters and for people working in hot or subzero environments.

Although it is believed that much of the fatigue of fire-fighting arises through the attack of smoke on the eyes, goggles are not favoured because the lenses quickly become dirty and distract the wearer. This difficulty has been partly overcome by placing wire gauze against the lenses; the eyes accommodate themselves to the uniform “ dirt ” pattern which in turn distracts the eyes from noticing the genuine smuts on the surface. Field experience is still required with these.

Attempts to fireproof bark have been encouraging and the laboratory findings have been checked under actual burning conditions, but further tests are required. A sufficiently cheap material would greatly improve fire-breaks and facilitate control burning. The use of explosives to fell burning trees when conventional methods are unsuitable is being examined.

(*j*) *Oxidaton with Air and Water.*—Many common materials such as paint break down rapidly under atmospheric conditions. Some of this breakdown is attributed to the formation of hydrogen peroxide, and methods of detecting peroxide have been examined. Other authorities have claimed that one of the more sensitive methods is to expose photographic plates to the area where peroxide is forming and then to develop the plate. The image forms on the plate, however, only if oxygen or hydrogen peroxide and water are present, although heat radiation also contributes to an unspecified extent. This phenomenon, known as the Russell effect, is shown by carbon blacks, but, in contradiction to results obtained by other workers, there is no obvious relation between fogging ability and the peroxide content of various carbons as determined by different chemical methods. The effect is strongest with red-sensitive plates, which do not respond to peroxide.

6. CHEMICAL PHYSICS.

(Division of Industrial Chemistry.)

(*a*) *Protein Structure Investigations.*—This work is described in Chapter XVI., Section 10.

(*b*) *Chemical Physics of the Solid State.*—Study has continued of the production and properties of various kinds of defect in crystals and their bearing on chemical and physical properties of solids.

Further theoretical work, based on calculations of the energy levels of clusters of *F* centres in ionic (alkali halide) crystals, has been conducted. Attempts have been made to interpret some of the phenomena of aggregation of *F* centres.

Study has proceeded on the mass transport in zinc oxide and on oxidation of the metal. The capacity-type differential manometer developed for this work has been refined, and an absolute gauge capable of measuring accurately to 10^{-4} mm. of mercury has resulted. Growth mechanisms of zinc crystal have been studied microscopically from both vapour and liquid phase.

The phosphorometer has yielded valuable results on the decay processes involved in solid-state phosphorescence. Instrumental techniques and numerical analyses have been improved greatly. One system is now being investigated in some detail, and the nature of decay mechanisms have been clairfied. It is clear that several processes proceed simultaneously.

Work has continued on the photoconductivity of cadmium sulphide. Single crystals and evaporated layers have been produced under a variety of conditions and their properties have been observed. Long-term exposure of the evaporated layers to an electric field results in electric breakdown of the crystals. Zone refining of the materials involved has been necessary to produce the required purity. The way in which optical absorption bands in solids change with temperature has also been studied. A theoretical model for optical phenomena associated with the long-wavelength absorption “ tail ” of evaporated layers has been studied, together with other departures of evaporated layers from ideal theoretical models used in the past.

(*c*) *Molecular Structure Studies.*—(i) *Electron-Impact Studies.*—A study has been made of the accuracy which can be obtained in the measurement of ion appearance potentials, using the second derivative method, and all the factors which affect the measurements have been carefully evaluated. It has been shown that under favourable conditions accuracies of ± 0.01 eV can be achieved, even though the electron beams used have energy spreads of 0.5 eV.

(ii) *Photochemistry.*—An examination has been made of the mercury-photosensitized reactions of hydrogen and carbon monoxide, as part of a more complete study of the formyl radical.

(iii) *Structure Analysis by Electron Diffraction Methods.*—Single-crystal studies on some aromatic polycarboxylic acids have revealed a remarkable range of disordered sublattices not detectable by X-ray diffraction methods.

(iv) *Calculation of Molecular Energy Levels.*—Previous calculations on the energy levels of any but the simplest diatomic molcules failed to yield results in agreement with the thermochemical and spectroscopic data. However, by taking into account the appropriate valence states of the atoms rather than their spectroscopic ground states, calculations have been made for the first-row hydrides (BH, CH, NH, OH, and FH) which account satisfactorily for their thermochemical and spectroscopic properties.

(*d*) *Development of Specialized Instruments and Techniques.*—The Section has continued the development of new techniques and the design and construction of new instruments for application to chemico-physical problems. Frequently, such instruments prove to be of wider use than was originally envisaged, and in several instances commercial instrument firms have shown interest in acquiring the manufacturing rights.

(i) *Optical and Spectroscopic Instruments.*—The Section has devoted an increasing effort to the design and development of optical and spectroscopic equipment. This work has necessitated the formation of a specialized optics group and the provision of facilities for making optical components.

Work has been devoted primarily to the development of apparatus for the solution of specific problems, with emphasis on simplicity of design and ease of production under Australian conditions. Instruments developed by the spectroscopic group are already being produced overseas, and the possibility is constantly kept in mind that these, and other instruments which may be developed in the future, will be manufactured in Australia.

A commercial high-performance spectrograph which normally requires to be operated in a room whose temperature is rigidly controlled has been redesigned. The redesign dispenses with the necessity for temperature control and greatly reduces the cost of manufacture and the difficulty of alignment. This is of special relevance to Australian conditions.

The problem of obtaining measurements of the light scattered by absorbing solutions—the so-called Raman spectrum—is one of long standing. A new type of Raman light source has been developed which is applicable to either coloured or colourless solutions. The new source is much simpler and cheaper than existing Raman sources.

During the year the vacuum ultraviolet spectrograph, built by the Section in 1951, has been converted to a monochromator. This employs a new type of concave-grating mounting which is of extreme simplicity and may find wide application in other spectroscopic instruments. An important characteristic of this new mounting is its compactness, a feature which is of particular value if the instrument has to be evacuated, as is necessary for the region below 1,800Å.

Encouraging preliminary results have been obtained from the application of the " curve follower ", described in last year's Annual Report, in the conversion of a single-beam, infra-red spectrometer to a double-beam spectrometer using the " memory " principle.

Attention has been devoted to the design of the electronic equipment, such as power supplies, amplifiers, recording systems, etc., which is used in the production and measurement of radiation. For example, the electronic equipment used in the atomic absorption spectrophotometers introduced and developed by the Chemical Physics Section has been greatly simplified, and several units have been produced by a local manufacturer.

(ii) *Electron-Microscope Instruments and Techniques.*—During the last decade, evidence has accumulated that it may be possible to devise electron lenses of a quality sufficient to permit the resolution of at least the heaviest atoms. To test this possibility a high-quality objective lens and power supply have been designed and are almost ready for installation in the Division's electron microscope.

The techniques used for the fixation and embedding of tissue for electron microscope examination are much less satisfactory for plant than for animal material. A critical examination is being made of the effectiveness of a variety of fixatives and embedding materials. The best results have been obtained in the study of young plant materials in which the cells closely resemble animal cells.

Much more uniform sections can be cut with ultramicrotomes if the specimen movement past the knife is extremely slow. A variety of mechanisms for achieving this without diminishing the rate of sectioning has been examined, and the most satisfactory has been built into a microtome developed in the Chemical Physics Section. An Australian company has begun manufacture of this type of ultramicrotome.

To build up a three-dimensional model of the cell structures observed in electron micrographs of tissue sections, it is necessary to examine a series of successive slices. Until recently the weakness of supporting films seriously limited this possibility. Composite films of plastic and evaporated carbon, lithium fluoride, or silicon monoxide have been developed which are so strong that they can be used to support ribbons of sections over areas 2 mm. in diameter without obstruction and which are sufficiently thin to permit use of the full resolving power of modern electron microscopes.

(iii) *Development of New Techniques in Structure Analysis—Physical Optics Theory.*—About three years ago, a chance observation led to the discovery of a new optical phenomenon, namely, the formation of multiple images of periodic objects without the aid of any lens or other optical component. These effects were interpreted theoretically and the results were checked by laboratory experiments with visible light. Magnified images of periodic objects could be obtained with good resolution merely by illuminating them with a suitable small source of light. By using electrons instead of light it may be possible to use this effect to improve the effective resolution of an electron microscope to the point where the atoms in a crystal lattice become visible.

The most far-reaching development from this observation, however, has arisen on the theoretical side. As the conventional methods of treating optical problems proved cumbersome when applied to the formation of the images of periodic objects, a new direction of attack was tried, making use of the properties of the convolution integrals widely used in the mathematical theory of diffraction processes. This method proved successful, and was generalized to form the basis for a new formulation of physical optics which could be applied to the solution of problems in many different fields, including radio astronomy, microscopy and telescopy with visible light, X-ray diffraction, electron diffraction and microscopy, and nuclear physics.

This new formulation has been applied to electron diffraction and microscopy. In these fields the theory generally used, the kinetic theory, is actually an approximation which is valid only for zero crystal thickness and may often be greatly in error in practice. The standard wave-mechanical, or dynamic, theory, although valid for crystals of any thickness, can be evaluated only in a few very specialized examples of limited interest. The new formulation has made possible a new line of attack on problems in this field. Although a completely general treatment of the scattering of electrons by crystals has not yet been made, interesting results have already been obtained for several problems which had previously proved intractable.

For example, the dependence on crystal thickness has been calculated for the intensities of the spots in the single-crystal spot patterns which form the basis of the techniques recently developed for determining the structure of sub-microscopic crystals. Previous predictions that increasing thickness would make the spot patterns unusable were wrong, but new, more powerful methods of structure analysis can be developed by making use of the variation with thickness.

Improvements in the technique of electron microscopy have enabled several electron microscopists to record periodic structures in images of crystals. They interpreted them as corresponding to the molecular structure of the crystals. The extent to which an electron microscope image of a crystal lattice can be said to represent the crystal structure was in doubt. The new formulation has supplied the answer. The kinematic theory arguments used to date to interpret the images of crystals are usually quite misleading and may give rise to false conclusions, especially when the crystals are bent or slightly out of focus, as often occurs.

Related subjects treated using the new formulation include the electron diffraction and microscopy of disordered crystals and of superimposed crystals giving rise to moire-like fringes and images related to the crystal lattice structure. Some work has been done on the degree of coherence of electron beams used experimentally, and on the scattering of electrons by atoms, which is of basic importance for structure analysis.

Applications of the formulation to radiation other than electron beams have not been developed to such an extent. Possible uses have been indicated in the design of light-optical instruments and instruments for radio astonomy. The mathematical techniques themselves may find application in the treatment of statistical problems.

The theoretical predictions have been tested by experiments with visible light and suitable test objects. The agreement obtained has invariably been good. Experiments with electrons to confirm directly the predictions relating to electron diffraction and microscopy have as yet been limited and of a rather qualitative nature.

(*e*) *Collaborative and Service Work.*—The following is a selection of problems undertaken for industry, universities, and other parts of the Organization:—

(i) *Electron Microscopy.*—Investigation of chloroplast and tonoplast structures; measurement of particle sizes in silver sols.

(ii) *X-ray Diffraction.*—Phase identification of silver iodide specimens; examination of cetyl alcohol samples.

(iii) *Electron Diffraction.*—Examination of corrosion products in gauges; surface contamination of molten silicon.

(iv) *Mass Spectroscopy.*—Measurement of H-D ratios in water samples; analysis of gaseous photochemical products; impurities in acetylene samples.

(v) *Spectroscopy.*—Infra-red spectroscopic study of quinolones, of Australian pitches, of *iso*thiocyanates, and of phthalimide derivatives; infra-red spectroscopic analysis of soil air samples and of cyanidation liquors; measurement of infra-red reflectance spectra. Spectrochemical analysis for trace elements in dried blood samples.

(*f*) *Instrument Laboratory.*—Major items completed his year include: Raman source, caesium iodide prism, counting head, split-beam photometer, photomultiplier power supplies and amplifiers, casing for electron microscope projector lens, mercury diffusion pumps, rebuilding of vibrating reed electrometer, and temperature-compensated mirror mount.

7. ORGANIC CHEMISTRY.

(Division of Industrial Chemistry.)

Research of the Section has received valuable stimulus from the support of an American pharmaceutical company, which has financed the appointment of a research officer and assistant to undertake the isolation and structure determination of new alkaloids. The company has also contributed towards the cost of collecting plant materials, will itself undertake the pharmacological assessment of crude alkaloidal extracts prepared in the Section, and will report on its findings.

The activities of the microanalytical laboratory, operated jointly with the Chemistry Department of the University of Melbourne, have continued unchanged. Other facilities of the Organic Chemistry Section have been of value to research workers from outside, particularly a vapour-phase chromatographic unit incorporating a robust but sensitive gas-density balance. The laboratory for large-scale operations has in the past supplied several plant extracts to University research workers engaged in the field of natural products. Recently installed equipment includes an extraction unit which replaces improvised units and is capable of handling 3-4 cwt. of material per batch.

(*a*) *Wool Wax.*—This work is described in Chapter XVI., Section 4.

(*b*) *Sugar Cane Wax.*—Following on the demonstration that the method of refining sugar cane wax with light petroleum and ethanol presented no difficulties when operated on a larger scale, the possible uses of the wax in wax emulsions of the " self-polishing " type have been examined. It proved possible to replace more than 80 per cent. of carnauba and other imported waxes in polishes of this type.

An approximate estimate of the cost of producing this type of wax has been made. Final costs are largely dependent on the cost of the crude wax made available, but a competitive price appears possible. The information obtained has been made available to the Bureau of Sugar Experiment Stations of Queensland, which has in hand the production of the crude wax.

The cost of the crude wax is such a large proportion of the final cost of the refined wax because about half is discarded as a fatty by-product with little or no market value as such. The conversion of this " fat " into materials of commercial value may be possible, as it contains among other ingredients 4 per cent. of sterols, of which a large proportion is stigmasterol.

(*c*) *Plant Alkaloids.*—The grant of £6,000 per annum from Smith, Kline, and French Laboratories to further work on the pharmacologically active constituents of Australian plants, and reference to which was made in the previous Annual Report, became effective from January, 1958. Already, sufficient species have been screened pharmacologically to permit a preliminary assessment of the results. Approximately 25 per cent. of the samples submitted have shown activity warranting isolation of the constituent alkaloids for further testing, and several samples have shown considerable promise. Some progress has been made with the investigation of certain of these more promising species. Several new alkaloids have been isolated in the course of the work.

Work has continued on the alkaloids of *Alstonia constricta, Kopsia longiflora, Cryptocarya pleurosperma,* and *Lunasia quercifolia.* The structure of the principal water-soluble *Lunasia* base has been determined, together with that of the artefact to which it gives rise under alkaline conditions. Further pharmacological testing of the vesicant alkaloid cryptopleurine, from the bark of *C. pleurosperma,* has been arranged, and the structure of another novel alkaloid from the leaves of this species is under examination.

In addition to general pharmacological screening, a number of substances, and extracts, have been submitted to the Victorian Cancer Institute Board and to the Cancer Chemotherapy National Service Centre (U.S.A.) for antitumour testing.

(*d*) *Stock Poisons.*—Collaboration has continued with the Division of Animal Health and Production (see Chapter V., Section 11 (e)) in the investigation of plants poisonous to stock. The problem of collecting materials for stock poison work and of making them available in bulk for laboratory work before they deteriorate has been solved by the provision by the Division of Animal Health and Production of a mobile crop drier. This equipment has proved very satisfactory under a variety of field conditions.

Further examples of non-esterified pyrrolizidine alkaloids have been isolated from *Crotalaria goreensis* and *C. anagyroides,* the major components of which have been found to be 7-hydroxy-1-methyl-1,2-dehydropyrrolizidine and 1-methylenepyrrolizidine respectively. Acute toxicity tests carried out by the Division of Animal Health and Production have shown that *C. lanceolata* contains one or more substances of very high toxicity, and isolation of these is being attempted. Efforts to isolate the previously reported mikanoidine from *Senecio mikanioides* were not successful; under Australian conditions the predominant alkaloid of this species is sarracine, which was found to be a diester of platynecine, the 7-hydroxyl group being esterified with angelic acid and the 1-hydroxymethyl group with sarracenic acid. A reinterpretation of data on the structure of jacobine, the principal alkaloid of *Senecio jacobea,* has been made by a guest worker. The proposed structure is not only consistent with the available evidence but also fits into the structural pattern of other *Senecio* alkaloids. A method has been devised for reforming an alkaloid such as heliotrine from its component acid and amino alcohol. The way is thus opened for systematic study of the structural features necessary for liver-damaging activity in this group of compounds. Work is proceeding to isolate the toxic principle of *Atalaya hemiglauca,* but attempts to obtain dry material of *Phalaris tuberosa* which will give rise to the " staggers " syndrome when fed to sheep have again been unsuccessful.

(*e*) *Root Exudates.*—Production of radish root exudate required for study of the *Pellicularia filamentosa* stimulant has now been placed on a satisfactory routine basis. Likewise, the bioassay method is now operating smoothly. Treatment of radish root exudate with ion-exchange resins has yielded three active fractions. Further attempts are in progress to isolate the stimulatory substances present in these fractions. Many water-soluble compounds of low molecular weight which might be expected to be present in the root exudate, including sugars, carboxylic acids, and vitamins, have been screened for ability to stimulate the growth of the fungus, but with the possible exception of nicotinamide all have proved to be inactive.

Investigation of *Backhousia angustifolia* in collaboration with the Division of Plant Industry (see Chapter III., Section 12 (*a*)) revealed that, although the species contains angustione, or dehydroangustione, both of which strongly inhibit germination of hoop pine and other species under laboratory conditions, the *B. angustifolia* litter had no influence on hoop pine germination in a field experiment.

Investigation of the root exudate of subterranean clover continues, to isolate substances believed to influence the course of nodulation by *Rhizobium*. A unit which maintains reproducible environmental conditions for growing the plants has been constructed and is operating successfully.

(*f*) *Fats and Related Long-chain Compounds*.—(i) *Insecticides*.—One group of naturally occurring insecticides of considerable potency is known to comprise the *iso*butylamides of polyunsaturated fatty acids. The length of the carbon chain in these active natural compounds ranges from ten to eighteen, and the degree and location of the unsaturation necessary are uncertain. The preparation of the *iso*butylamides of several long-chain unsaturated acids has been undertaken to discover the structural features needed for high insecticidal action. The carbon chain length chosen for these compounds was 16, being that present in the widely available palmitic acid. The *iso*butylamides of all four possible 2, 4-hexadecadienoic acids have now been prepared and submitted to the Division of Entomology for testing.

(ii) *Tigaso Oil*.—Tigaso oil from a New Guinea tree *Campnosperma brevipetiolata* of the Anacardiaceae is still under investigation. A complete structure has been assigned to its optically active, non-phenolic compound. It represents a new type of long-chain alkylated hydroxy-*cyclo*hexane and displays interesting biogenetic relationships to the characteristic vesicant phenols of this family of the Anacardiaceae. One of the obscure chemical reactions of this interesting compound has now been made clear. In cold alcoholic alkali it cyclizes rapidly, with optical inversion, yielding a long-chain bi*cyclo*-nonane derivative; in warm alkali this reacts with optical inversion to produce a 1,3-cyclic diketone.

The principal constituents of the exudate from a related species, *Campnosperma auriculata* from Malaya, have been identified; in addition to the chemicals reported previously, it has now been found to contain small quantities of long-chain-substituted quinols, and provides the first example of the natural occurrence of dihydric phenols of this class.

(iii) *Chemistry of Fatty Acids*.—The competition between synthetic surface active agents and soaps makes it increasingly difficult to absorb surplus animal fats, and for this reason two new investigations related to the chemistry of fatty acids have been commenced. The first concerns the preparation of substituted sebacic acids that could be of value as plasticizers and as low-temperature lubricants. It has been confirmed that the *erythro*-dihydroxy stearic acid prepared from oleic acid was transformed in fused alkali to α-hydroxy-α-octylsebacic acid, and it has also been shown that the isomeric dihydroxystearic acid, now the more easily prepared from oleic acid, is likewise convertible to this substituted sebacic acid. Considerably improved yields have been obtained. Conversion can be achieved in aqueous alkali under pressure, but with, as yet, diminished yield.

Esters of this hydroxyoctylsebacic acid have been shown to be efficient plasticizers for polyvinyl chloride.

The second investigation seeking the means to attack long-chain compounds such as stearic acid at positions normally unreactive has continued. The procedure examined involved the use of strong oxidizing agents upon the material, which could be stearic acid, while firmly adsorbed. Several agents were tried under a range of conditions without achieving any certain result, until it was discovered that in the crystal of the organic chemical the normally reactive positions were sufficiently protected from attack and positions usually viewed as inert were vulnerable. For example, cholesterol in the crystalline condition is oxidized preferentially at the 26 position by Fenton's reagent.

(*g*) *Phenols of Brown Coal Tar*.—Investigation continued on the separation of phenols from the tar produced in the gasification of brown coal by the Lurgi process.

(*h*) *Miscellaneous*.—Some early observations in terpene chemistry have been interpreted in terms of stereochemical theory. Configurations have been assigned to nine compounds and the mode of addition of the elements of water to olefines has been discussed.

8. Chemical Engineering.

(Division of Industrial Chemistry.)

In an attempt to meet the demand from industry for services, it is proposed to extend considerably the scope of the Section's activities and to subdivide the Section into three main groups: a process group, which will incorporate most of the activities of the Section as at present constituted, a unit operations group, and a fundamental group. Steps have been taken to recruit a leader for the unit operations group, and work will be instituted as soon as possible on operations involving solids handling, e.g. comminution and solids separation. The work for the past year, however, has followed mainly on the same lines as those of the previous year.

(*a*) *Utilization of Brown Coal*.—This work is described in Chapter XIX., Section 5.

(*b*) *General Process Development*.—(i) *Fluidized Bed Roasting of Copper Concentrates*.—Experimental work associated with the programme of tests in the 12-in. diameter roaster was completed early in the year. Following the completion of calcine leaching and electrolysis experiments by the Minerals Utilization Section of the Division, an evaluation of the overall process was undertaken. This work is reported under the heading of Minerals Utilization (see Section 2 (*a*)).

(ii) *Rutile from Ilmenite*.—Under the sponsorship of four Australian companies, work commenced in 1957 on a project aimed at the evaluation and development of a new process for the production of granular rutile from ilmenite. This process consists of two main stages, namely, the reaction of ilmenite with sulphur vapour at 700-850° C., and a hydrothermal oxidation of the sulphided product, performed in an autoclave at 100-140° C. In the second stage, iron compounds are removed, leaving skeletal aggregates of substantially pure titanium dioxide, and elemental sulphur is recovered.

Study of the ilmenite-sulphur system has been performed in a small, batch-operated, fluidized bed reactor. This has provided quantitative information on the conditions required for production of an optimum product, and the factors influencing sulphur utilization. Design data for a practical reaction system have also been obtained. Attention is now being directed to a systematic study of the second stage of the process, and to methods of separating contaminant materials other than iron from rutile.

(*c*) *Process Equipment Laboratory*.—This laboratory provides a range of chemical processing equipment which, in addition to meeting the requirements of the Division, is available for use by other Government departments and by private firms. During the year the laboratory handled six projects from within the Division, and with staff provided by the companies fourteen projects were undertaken for private industry.

Assistance was given to the Department of Defence Production in developing a process for producing *iso*propyl acetate which was urgently required by the Royal Australian Air Force.

Work on the utilization of solar energy continued and included studies on the commercial drying of grapes and peanuts. Assistance was also given to the Physical Chemistry Section on the bushfire project.

XVIII. MINERAGRAPHY AND ORE-DRESSING.

1. General.

For the past century, mining has been one of the major ndustries in Australia, and wealth from mineral resources constitutes a large proportion of the nation's export ncome. Mineragraphic work to provide information on the mineral composition of ores has been an important field of investigations for the Organization and its predecessors. The techniques used are highly specialized and require considerable experience, so that it is only rarely that they can be applied by the staffs of operating mines. The current work of the Mineragraphic Investigations Section is described in Section 2 of this Chapter.

The Ore-dressing Laboratories operated in Melbourne in collaboration with the University Department of Mining, and in Kalgoorlie in co-operation with the School of Mines, investigate the composition of ores and provide advice on suitable methods for their full-scale treatment. This work is reported in Sections 3 and 4 of this Chapter.

Work on the utilization of minerals is carried out by the Division of Industrial Chemistry (see Chapter XVII., Section 2).

Mineragraphic Investigations Section.—Research programmes of the Section have continued unchanged. Forty-eight investigations have been made during the year of mill products, drill cores, mineral associations, and rocks submitted by mining companies, other establishments of the Organization, and Government Departments.

Investigation has been facilitated by contributions from a number of mining companies through the Australasian Institute of Mining and Metallurgy.

Ore-dressing Laboratory, Melbourne.—The growth of co-operative investigations undertaken for mining companies continued throughout the year. Two important investigations, the flotation of base metal ores from Rum Jungle, Northern Territory, and the concentration of oolitic iron ores from Roper Bar, Northern Territory, were advanced. Many problems associated with a proposed expansion of production at Wattle Gully Gold Mines N.L. were examined, and in addition several smaller investigations undertaken for mining companies were sponsored on a cost basis. These investigations have resulted in liberal donations by mining companies to the funds of the Section.

A modified reporting practice has been adopted for sponsored investigations. The reports are retained as confidential for a longer period than formerly, but it is anticipated that all the work of the Section will eventually appear as published reports.

The Laboratory has this year received an increased number of requests for the services of staff for field consultations.

Ore-dressing Laboratory, Kalgoorlie.—The research of the Laboratory has continued as in previous years.

Eleven reports of investigations and 69 certificates were issued from the Kalgoorlie Metallurgical Laboratory. Six of the reports referred to gold ores, one to a copper ore, one to a copper-cobalt ore, and the remaining three to non-metallics.

During the year, officers of the Laboratory made visits to Christmas Island, Bunbury, and Capel to advise on mining operations.

2. Mineragraphic Investigations.

(Mineragraphic Investigations Section.)

A study of nickel mineralization in western Tasmania revealed four distinctive mineral associations, containing between them sixteen different species of primary nickel minerals, and drew attention to the possible existence of extensive low-grade nickel sulphide mineralization associated with areas of ultrabasic igneous rocks in this part of Tasmania. A new nickel mineral, a hexahydrate nickel carbonate (hellyerite), was discovered in one deposit. The occurrence of nickel and chromium near Beaconsfield in northern Tasmania was investigated. Nickeliferous cobaltite was described from the Ortona mine, Queensland, and various rocks from New Guinea were examined for the presence of nickel.

Study of drill cores of an oolitic iron formation from the Constance Range area of north-west Queensland demonstrated that the outcropping beds pass, below the zone of oxidation, into beds of oolitic haematite and chamosite in a siderite matrix, which locally constitute shipping grade ore. These deposits warrant further exploration in view of their known extent. The possibility that a similar relation could apply to the oolitic iron formation of Arnhem Land, studied during the previous year, has led to drilling of some of the deeper section of the Arnhem Land formation, with the discovery of a siderite formation there also.

An examination was made also of drill cores from iron ore in the Savage River district of western Tasmania, with special reference to the occurrence of titanium in it.

The mineral composition of the bauxites of Weipa, Queensland, is being investigated, following a visit to the area. The size and distribution of quartz and heavy minerals (mainly zircon, rutile, tourmaline, and leucoxene) have been studied, and the relative distribution of boehmite and gibbsite is being studied.

The mineralization in exploratory drill holes at Peko, Northern Territory, are under investigation.

A uranium concentrate from South Alligator River, Northern Territory, yielded a variety of relatively rare secondary uranium minerals, as did further specimens from the Milestone Lease, Northern Territory. Manganeses ores from Heyfield, Victoria, Rippon Hills, Western Australia, and Gebore, New Guinea, were examined. Drill core samples from Komewu No. 1 well, Papua, were identified.

Tin ores were examined from Nymbool, Queensland, Renison Bill, Tasmania, and Mount Wells, Northern Territory.

Beach sands containing valuable minerals have been examined from Bagama and Southport, Queensland, and from north-west Western Australia.

Copper selenides were found associated with gold tellurides in the ore of the Phantom and Phantom South lodes, Kalgoorlie, Western Australia.

Studies have been made of the gold ores of the Maude and Yellow Girl Mine, Victoria, and an investigation has been made of a pyritiferous breccia from Golden Ridges, New Guinea (Wau). The rare mineral, berthierite, $FeSb_5$, was found associated with stibnite at Steel's Creek, Victoria.

3. Ore-dressing Investigations.

(Melbourne Laboratory.)

This year's work for the Laboratory again covers a wide field. Beach sands and ores of iron, lead, copper, tin, gold, manganese, tungsten, and uranium are being investigated as well as ores of fluorite and beryl, while several investigations are devoted solely to the properties of minerals for particular uses. Twenty reports and two information circulars were issued.

Work on beach sands from northern areas declined, owing largely to the sharp drop in the price of rutile. Some progress has been made in developing the better methods of recovering monazite, a mineral of growing interest in the field of atomic energy. Extensive investigations have been undertaken of methods for recovering ilmenite and other minerals from Western Australian beach sand deposits, which seem likely to contribute substantially to world resources of ilmenite.

Work on the concentration of uranium ore is expanding. It appears likely that some Australian uranium deposits cannot be exploited economically by direct chemical extraction. It is expected that several reports on the concentration of uranium ores will be published within the ensuing year.

A detailed investigation was undertaken of the behaviour of oolitic iron ores both in direct magnetic concentration and in magnetic concentration after reduction roasting.

In investigating the flotation treatment of base metal ores from Rum Jungle, attention was directed mainly to the lead-bearing ores which do not respond to the special conditioning procedure which was successful for copper-bearing ores in close proximity to them. In flotation of the lead ores the control of readily flotable silicious gangue was substantially improved by optimum adjustment of pH, together with type and amount of depressant reagents.

Two papers relating to the pressure leaching of manganese ores were published. It is hoped to extend these investigations to cover cobalt minerals with the eventual objective of developing a process for treating cobaltiferous wad ores.

A chromatographic method for estimating gold in ores has been developed. The traditional prospector's tool, the panning dish, fails to detect ultra-fine gold. The chromatographic method can give, in the field, rapid results of an accuracy adequate for prospecting purposes for many types of gold ore. The technique can be learnt rapidly by untrained personnel, and the capital outlay and running costs are moderate.

For the Wattle Gully gold-mine, which is contemplating plant expansion, the recovery of coarse gold, the flotation of gold-bearing sulphides, grindability of ore, cyanidation of concentrates, and other problems were investigated in a comprehensive test programme.

Several investigations were concerned with the properties of minerals as they affected handling and uses. The slump angle for ilmenite, pyrite, gypsum, and other minerals shipped in bulk was investigated, and the effect of moisture content on slump angle determined. These properties influence shipping regulations. The pelletizing of " Kopi " (the fine-grained overburden of gypsum deposits) was investigated. This material is a promising source of sulphur for fertilizer purposes if its handling properties can be improved. A highly magnetic by-product from beach sand concentration plants was examined as a possible source of make-up mineral for heavy-media separation plants.

At the request of the Division of Industrial Chemistry an investigation was made of the extraction of gold from calcines produced by fluid-bed roasting of copper concentrates.

4. Ore-dressing Investigations.

(Kalgoorlie Laboratory.)

Further work was done on phosphate rock from Christmas Island (Indian Ocean). Pilot-plant tests showed that the Dietrich and Buell dryers in use on the Island were not suitable for combined drying and attrition grinding necessary to reduce the iron oxide and alumina to the required level. It appeared, however, that drying followed by sizing—either screening or air sizing—would give two products, one of which would be suitable for blending with higher-grade lower layer phosphate rock and the other for sale after grinding as phosphate dust. Recommendations for future work were made to the Commission, and it is believed that sufficient has been done to show that the upper layer phosphate rock can be beneficiated and used with the lower layer rock.

Research has continued on the graphite ore from Munglinup. A good grade of graphite can be produced from this ore, and it was hoped that during this year some production would be possible. However, this has not been possible mainly because of shipping and other difficulties associated with location of the ore.

Treatment tests for plant design purposes were done on high-grade gold ore from the Hill 50 Eclipse Mine, Mount Magnet. These tests showed that a satisfactory recovery of gold could be obtained by straking followed by cyanidation. The ore filtered well and settled readily. Hydrocyclones could be used to thicken the feed to the agitators. A plant is now being erected.

Concentration tests were carried out on an oxidized copper ore from the vicinity of Marble Bar. Malachite was the main copper mineral in the ore, but small quantities of sulphide were present. Tests showed that up to 98 per cent. of the copper in the ore could be obtained in a flotation concentrate assaying 40 per cent. copper.

A copper-cobalt ore from the old Carlow Castle Mine near Roebourne was not amenable to gravity concentration. Concentrates of marketable grade could be produced by flotation, but the recovery of copper and cobalt was low.

Beneficiation tests were carried out on a spodumene ore from Ravensthorpe. A spodumene concentrate assaying approximately 5.4 per cent. lithium oxide was recovered. This concentrate also contained some sphalerite and assayed 1.2 per cent. zinc.

Sands from the vicinity of Capel yielded a clean ilmenite concentrate of marketable grade after gravity concentration and magnetic separation.

XIX. FUEL.

1. General.

Coal, which is Australia's principal source of energy, is a material of widely varying qualities, and deposits which are suitable for specific purposes should not be used indiscriminately. Available reserves of the more valuable types of coal are limited, and it is essential that a complete survey is made of their properties in order that they are used to the best advantage.

The Organization's main centre for investigation on fuels is the Coal Research Section, located at North Ryde, New South Wales. This Section was established to undertake, on a national basis, a comprehensive study of the physical and chemical characteristics of Australian coals. It aims to promote the more efficient use and economic development of coal resources, by increasing the efficiency of carbonization, gasification, and combustion processes, and by improving the quality of coal grades through cleaning, preparation, and pretreatment appropriate to specific industrial needs.

The Division of Industrial Chemistry is undertaking work on the engineering aspects of the gasification of low-rank coals, and this work is reported in Section 5 of this Chapter. Research on the chemistry of tar from Lurgi gasification plant is reported in Chapter XVII., Section 5 (*c*).

Co-operative investigations on the fossil pollens in brown coal are undertaken in the Botany School of the University of Melbourne (see Section 4 of this Chapter).

Coal Research Section.—The research programmes of the Section have continued unchanged.

Work was commenced on the construction of two new permanent single-storey buildings. The larger of these will be used for pilot-plant and semi-industrial-scale work on carbonization research projects; the other will house the Section's workshop.

Following the success of the Section's first symposium on " The Production, Properties, and Utilization of Foundry Coke " held in 1956, a second symposium on the same subject was held in the Section during the year. Representatives of the coke manufacturers, the iron and steel industry, and the foundry industry as well as officers of the Section contributed to the meeting. The delegates agreed that the quality of coke had improved greatly following the first symposium.

The gift is gratefully acknowledged of an automatic, recording, double-beam, infra-red spectrophotometer donated by Bowen Consolidated Coal Mines Limited.

2. COAL UTILIZATION.

(Coal Research Section.)

(*a*) *Carbonization Investigations.*—(i) *General.*—The past few years have seen a rising demand for coke for blast furnace, smelting, and foundry purposes, and this trend is likely to continue. There is also a demand for an improvement in coke quality. On the other hand, the reserves of the best coking coals are limited. The Section continued research into both, improving further the quality of coke made at present from our better coking coals, and making good-quality coke from the poorer coking coals.

Pilot-plant carbonization tests were undertaken to study blending and modification of the technique of carbonization, and also the physical and chemical processes occurring during carbonization.

(ii) *Pilot-plant Investigations.*—Pilot-plant equipment was used for investigation into the coking properties of mixtures of coals from the Bulli and Wongawilli seams (Southern Coalfield, New South Wales), and two most important sources of coking coal in the Southern Coalfield. Coal from the Bulli seam is used alone at a number of beehive coke-oven plants, but coal from the Wongawilli seam, because of its high vitrite content and consequent highly swelling natures, is usually blended.

The blends of these coals which produce the best metallurgical coke generally have vitrite content of 30-45 per cent.; fluidities, as measured by the Gieseler plastometer, of between 50 and 1,000 dial divisions per minute; and volatile matter content (d.a.f.) of between 23.5 and 28 per cent.

As much as 40 per cent. of weakly coking coal could be incorporated in blends of the more strongly coking Bulli coal and Wongawilli coal, without lowering the quality of the resultant coke, provided that sufficient Wongawilli coal was present to maintain a reasonably high vitrite content and fluidity.

The addition of 5-20 per cent. of finely divided low-temperature char to the coal blends appreciably improved the resistance of the resultant cokes to abrasion. The addition of only 5 per cent. of high-temperature coke fines to blends containing 40 per cent. of Wongawilli seam coal led to a marked improvement in the blockiness and shatter strength of the resulting cokes.

Methods are being studied of producing better metallurgical coke from the coking coals of the Newcastle district, Northern Coalfield, New South Wales. The importance of this work has been emphasized by plans to establish, in the near future, a new smelting plant at Cockle Creek, in the same district. The particular type of smelter to be installed consumes large quantities of metallurgical coke, which must be very strong and conform to exacting requirements. Because of high freight costs, it is desirable that this coke be made, as far as possible, from coking coals available locally.

Coal samples from five collieries in this district were carbonized, representing the Victoria Tunnel, Borehole, and Young Wallsend seams. These coals have in general good coking properties, but certain physical characteristics of the cokes produced could be improved by blending and by otherwise adjusting the coal charged into the retorts.

Work was continued on the evaluation of the carbonizing properties of Queensland coals. Coal from the Portland No. 1 seam at Globe Mine, Maryborough district, produced coke with a regular, fine texture and an exceptionally high resistance to abrasion; however, extensive fissuring occurred during carbonization. The coke produced from this coal alone would be suitable for processes which require a relatively small-sized, tough coke and where high phosphorus content in coke would be no serious disadvantage. Coal from the Excel seam, Excel No. 2 Mine, Bluff district, was also examined. This coal would not produce coke under normal conditions of carbonizing.

(iii) *Studies of Low-temperature Carbonization.*—A small-scale fluidized-bed apparatus has been constructed to provide samples of low temperature char from coals from the Northern Coalfield of New South Wales for the blending experiments described above, and to supply design information and process data for a larger-scale plant at present under construction.

(iv) *Bulk Density Investigations.*—The bulk density of crushed coal is an important factor in the production of metallurgical coke, as it not only determines the coking capacity of the oven but also affects the quality of coke and by-products.

Experiments on run-of-mine coal from Coal Cliff Colliery (Bulli seam, Southern Coalfield, New South Wales) showed that adding 0.2-0.4 per cent. of a light paraffinic oil increased the bulk density by several pounds per cubic foot and reduced its susceptibility to moisture changes.

(v) *Fundamental Coking Phenomena.*—Investigations on aspects of the coking process include: petrographic investigations; determination of the plastic properties of coal; measurement by means of the differential thermogravimetric balance of the rates of evolution of the various constituents of the volatile matter; microscopical examination; solvent extraction of partly carbonized samples of coal; and investigations into the chemical mechanism of the formation of coke from coal.

By studying the pyrolytic reactions and coking of model organic compounds, in this case some condensed polynuclear quinones, information is being gained on the behaviour during heating of chemical groupings and structures thought to be part of the coal molecule. The quinones being used are various vat dyes, which on heating within the range 330-550° C. generally form swollen agglomerates resembling semi-cokes from coal. Suggestions have been put forward on the probable chemical structure of these agglomerates, based on a comparison of their infra-red and electronic spectra with those of the parent quinones. On heating the agglomerates above 550° C., cokes and chars are formed which resemble high-temperature cokes from coal in their chemical structure.

The volatile matter given off by the model compounds on heating was found to contain significant amounts of the parent hydrocarbons, which suggests that large condensed hydrocarbon molecules are evolved during the carbonization of coal. Moreover, it would seem unlikely that rigid relationships exist between the chemical structure of coal and the volatile matter evolved during carbonization, since the experiments with the model compounds showed that small differences in their chemical structure caused pronounced variations in the mechanism of evolution of volatile matter.

A comparative study was made of the changes occurring on heating six New South Wales coking coals of differing rank and petrographic composition, representing the Homeville, Liddell, Borehole, Bulli, and Wongawilli seams. Each coal, according to rank, petrographic composition, and treatment, has its characteristic interrelated patterns of fluidity, swelling, and decomposition. The interplay of these factors apparently controls the course of coking and the properties of the resultant coke.

In general, it was found, the transition from coal to semi-coke exhibits five phases, viz.: 350-370° C.—softening of the vitrite grains; 370-390° C.—formation of gas vesicles; 390-415° C.—growth of the gas vesicles and swelling of the grains; 415-430° C.—the fusion of inflated grains into a completely formed cellular structure; and 430° C. onwards—active decomposition, rapid loss of volatile matter, and eventual solidification, without, however, further alteration in the microscopic structure. The mechanical characteristics of the coke other than cellular structure originate betwen 430 and 530° C.

Up to 500° C. most of the volatile matter may be condensed as tars and liquor, and only a small proportion of non-condensible gas is formed, which contains over 50 per cent. by weight of carbon dioxide, as well as carbon monoxide and nitrogen. From 500 to 525° C., the gas consists mainly of methane, ethane, and carbon dioxide with some carbon monoxide and hydrogen. Most of the gas, however, arises from the decomposition of the semi-coke and coke; from 525 to 700° C. it consists mainly of methane and hydrogen with some carbon monoxide, and above 700° C. mainly of hydrogen with some methane, carbon monoxide, and nitrogen.

To produce well-fused, strong, and dense coke the following three conditions should be satisfied. Firstly, a high proportion of coal grains should soften and distend with sufficient internal gas pressure to cause them to fuse together and to wet and mould around inert grains. Secondly, the extent and rate of evolution of volatile matter should be the minimum necessary, consistent with the above conditions of fusion and swelling, to give solidity and hardness to the coke. Thirdly, the solidification point of the plastic coal should be as high as possible so as to allow the maximum release of volatile matter while still plastic; the coke is then fissured and more resistant to shatter.

(*b*) *Chemicals from Coal.*—(i) *Properties of Light Oils, Tars, and Pitches.*—In view of the importance of the utilization of coal as a raw material for the manufacture of chemicals, the Section is continuing investigations into the properties, composition, and structure of light oils, tars, and pitches produced by the carbonization of Australian coals. A better understanding of the properties and nature of these materials would also contribute to their more efficient utilization in other ways.

Investigation was made of tars and pitches from the coke oven plant at the B.H.P. steelworks, Newcastle, and from the continuous vertical retort plant at the Mortlake works of the Australian Gas Light Company.

The composition is being studied of the insoluble tar and pitch fractions of higher molecular weight (the " crystalloids ", " resinoids ", " C_1 ", and " C_2 ") and the way in which the constituents of these fractions are associated. The phenolic hydroxyl and basic nitrogen groups have been estimated by non-aqueous potentiometric titration, molecular weight determinations, and infra-red spectometry. The distribution and concentration of these groups indicate that coal-tar pitches are solutions of polar compounds of medium molecular weight in solvents which are relatively non-polar.

(ii) *Chemistry of Brown Coals.*—Investigations continue into the chemical structure of brown coal, to provide basic data for the production of chemicals from this material.

Examination of the infra-red spectra of Victorian brown coals indicated the presence of hydrogen-bonded hydroxyl, aliphatic CH, and carboxylic carbonyl groups, and possibly aromatic ring structures and ether groups.

The pyrolytic decomposition reactions of Victorian brown coals were studied. Dehydration reactions play a major part in the decomposition and changes occur in the substitution pattern of the aromatic structures.

Samples of brown and sub-bituminous coals were treated with alcoholic or aqueous alkali at about 190° C. for about 12 hr., followed by acidification. The end products fused on pyrolysis in a crucible test gave coherent swollen cokes. The original coals were non-agglomerating when pyrolysed under the same conditions. On the other hand, examination of alkali-soluble and alkali-insoluble fractions, obtained from Victorian brown coals by refluxing for 1 hr. with 2N sodium hydroxide solution, revealed that these fractions do not differ chemically from each other or from the parent coal to any important degree. Their solubility behaviour is probably due to molecular-weight distribution or to purely physical differences.

The reaction of gaseous oxygen with Victorian brown coals was investigated at room temperature in the presence of alkali. The composition of the water-insoluble oxidation products, as well as the stoichiometry and kinetics of the reaction, indicated cleavage of phenolic nuclei to carboxylic acids and carbon dioxide. The aliphatic portion of the coal structure appeared to remain unaffected.

(*c*) *Combustion and Gasification Investigations.*—(i) *General.*—Work was continued on the combustion and clinkering characteristics of Queensland coals. Coals from the Portland No. 1 seam at Globe Mine and from the Excel seam at Excel No. 2 Mine were burnt in laboratory pot furnaces, which simulate underfeed and overfeed conditions. Overfeed firing without grit recirculation would produce high carry-over losses. Both coals have low ash-fusion temperatures and would be liable to cause slagging of combustion-chamber walls. Both coals have a high phosphorus content, that of the Portland seam coal being very high; formation of hard deposits then is likely on the external heating surfaces of boilers.

Coal washing, which is being increasingly practised at Australian collieries, gives in many cases a middlings product containing from 20 to 35 per cent. of ash. To evaluate the possibility of utilizing this type of fuel on a travelling-grate stoker, middlings from the Stockrington Washery were examined in pot-furnace experiments. Both ignition and combustion difficulties were overcome by crushing the fuel to a size below ½ in. In large-scale plant it should be possible, by using this smaller-sized fuel, to achieve higher burning rates than with the uncrushed fuel and also to reduce considerably both the ash pit loss and the air required for gasifying the fuel.

An evaluation was made of the combustion characteristics under overfeed and travelling-grate firing conditions of various other coals from the Northern Coalfield, New South Wales, viz. coals from the Bloomfield Colliery (Big Ben seam), the Northern Extended Colliery (Fassifern seam), the Northern Colliery (Great Northern seam), and the State Coal Mine (Liddell seam).

(ii) *Utilization of Coke.*—Methods are being studied of improving the utilization of metallurgical coke in industrial appliances. Experiments were made with a two-dimensional model cupola to determine the effect of coke size in relation to cupola dimensions upon the flow pattern and the pressure at the tuyères. The width of the cupola is the most important variable, while depth of well below the tuyères and even tuyère size have only a relatively small effect upon the value of the pressure gradient in the coke bed. Tests with various coke sizes and cupola widths indicated that the velocity distribution is far from uniform and that at the side walls the velocity may be three times the average value owing to the increased voidage. Because of this effect, the combustion zone in a cupola in practice is found close to the wall above the tuyères.

(iii) *Physical Structure of Cokes.*—The rate at which coke reacts with steam when it is being gasified, for example in a gas producer, is determined to a large extent by the volume, shape, and internal surface area of the pores.

The changes in the pore structure of cokes, carbonized at different temperatures and gasified for varying lengths of time with steam, were investigated by studying changes in internal surface area, apparent specific volume in various liquids, and degree of penetration of mercury under pressure. The existence has been demonstrated of two distinct pore systems in the coke structure: macropores with entrances in the range 130,000-400 Å diameter, the majority occurring in the region of 7,600 Å; micropores with entrances less than 10 Å diameter.

In the cokes examined no pores were found to exist with entrances in the range 10-400Å diameter.

The macropores contain many constructions, the number of which probably increases as the carbonization temperature increases to 700° C. but remains constant above this temperature.

The micropores consist of two types: pores approximately cylindrical in form and less than 10 Å in diameter, and those greater than 10 Å in diameter but with "bottle-neck" entrances. As the carbonization temperature increases the accessibility of both types of micropores decreases.

Preliminary gasification tests with steam at 800° C. indicate that the reaction takes place at all the internal surfaces of the coke, causing a widening of the constrictions in the micropore structure and a steady increase in the total pore volume.

3. EXAMINATION OF COAL SEAMS.

(Coal Research Section.)

(*a*) *General.*—Coals from six collieries in the Southern and South-western Coalfields of New South Wales were examined as well as three bore cores obtained from bores sunk in this area. Samples from 30 collieries and from nine bores in these coalfields have now been examined, representing the Bulli, Wongawilli, Tongarra, American Creek, and Woonona seams. Most of the collieries have been sampled twice, the first samples having been taken three-four years previously.

In the Newcastle district of the Northern Coalfield of New South Wales profile samples were taken at seventeen collieries representing the Great Northern, Fassifern, Young Wallsend, Borehole, Victoria Tunnel, Wavehill, and Dudley seams. In the East Maitland and Maitland-Cessnock-Greta districts, three collieries were sampled representing the Big Ben, Donaldson, and Homeville seams. Work in this coalfield is continuing.

Queensland coals were examined from the Excel seam at Excel No. 2 Mine, Bluff district; from the Portland No. 1 seam at Globe Mine, Maryborough district; from trial shaft No. S2 sunk on the Kianga Coalfield, Rockhampton district; and from Box Flat, Bundambah district.

(*b*) *Mineral Matter in Coal.*—Two methods for the direct estimation of the quantity of mineral matter in coal have been investigated and their reliability established. The methods make use of totally different approaches: in one, the mineral matter is decomposed by acid digestion and the organic matter left intact, while in the other, the organic matter is removed by low-temperature oxidation of the coal at 360° C. This investigation has demonstrated the extent of the errors arising from the use of empirical calculations for mineral-matter content.

4. MICROSTRUCTURE OF BROWN COAL.

(Pollen Research Unit.)

The Pollen Research Unit, at the Botany School, University of Melbourne, has concentrated on the taxonomy and distribution of certain megaspores and microspores that characterize the Upper Mesozoic sediments of eastern Australia. Two megaspore genera, previously known only from Britain and Europe, have been used in the correlation of freshwater deposits in South Australia, Victoria, and the Great Artesian Basin.

The study of fossil microplankton has been extended to Upper Mesozoic formations, and these fossils have proved valuable in dating formations of otherwise uncertain age in the Canning and Perth basins of Western Australia.

Research has been carried out on fossil woods of Yallourn and Bacchus Marsh brown coals, and a study of variation in distribution of tree varieties during the period of coal deposition is in progress. This is coupled with a study of possible cyclic changes in the environment of deposition, as revealed by pollen.

Quaternary deposits from New Guinea are being investigated for recent vegetational changes.

5. UTILIZATION OF LOW-RANK COAL.

(Division of Industrial Chemistry.)

(*a*) *Utilization of Brown Coal.*—(i) *Gasification of Brown Coal with Hydrogen.*—Experiments on the production of methane by direct hydrogenation of brown coal have continued, using the same three-inch diameter, continuously operated, fluidized bed unit. The temperature range studied has been extended to 950° C., enabling up to 82 per cent. of the coal to be gasified, with yields up to 15 cu. ft. methane/lb. coal (both on a dry, ash-free basis). At the highest temperatures, the net hydrogen consumption per cubic foot of methane produced decreased slightly.

Under these conditions some reaction appears to occur between the carbon and the water released from the coal, despite the high partial pressure of the hydrogen.

In a further series of runs the effect was studied of a high methane content (up to 30 per cent.) in the hydrogenating gas. Provided equilibrium is not attained, the methane acts purely as an inert diluent and has no effect on the hydrogenation rate.

Material balances for the experimental runs have been sufficiently precise to enable the exothermic heat of reaction to be calculated. This is found to be considerably less than for the hydrogenation of bituminous coals and semi-cokes, although, as might be expected, the heat evolved per mole of methane formed increases with the degree of gasification of the brown coal. Assuming autogenous operation of the reactor, about 80 per cent. of the coal must be gasified to satisfy the heat balance, even if coal hydrogenation is being used only to enrich Lurgi gas.

To produce a gas of more than 500 B.t.u./cu. ft. calorific value with a high proportion (more than 80 per cent.) of the coal gasified, a new reactor has been designed to give counter-flow of gas and coal in a fluidized bed 20 feet high. Construction of this reactor is now proceeding.

(ii) *Basic Studies of Carbon-Hydrogen Reaction.*—In a previous investigation of the kinetic features of the reaction of steam with ash-free coconut char in a pressurized system, it had been shown that in certain circumstances (e.g. when the reaction is retarded by hydrogen) a high proportion of the carbon gasified appears as methane. The rate of methane formation was found to be directly proportional to the steam partial pressure and independent of the hydrogen partial pressure.

In a new series of experiments, the same type of carbon was reacted with hydrogen alone. In this instance, the rate of methane formation, at a given temperature, was found to be directly proportional to the hydrogen partial pressure. When the hydrogen partial pressure was equal to that used in the earlier steam-carbon experiments, the rate of methane formation was generally less than one-twentieth of the rate observed in the reaction with steam. This confirmed the earlier conclusion that in the steam-carbon experiments nearly all the methane must have been formed by some mechanism other than direct carbon-hydrogen reaction.

As there was some evidence that oxygen transferred to the carbon surface from steam facilitated methane formation during the steam-carbon reaction, a study was made of the hydrogenation of chars of different oxygen contents. These chars were prepared by carbonization of low-ash jarrah wood at different temperatures in the range 650-1,150° C. When these chars were reacted at 650° C. with hydrogen in the pressure range 30-50 atm., the methane formation rate was initially very high, and the quantity of methane formed could be related to the loss of oxygen from the char. The rate fell quickly to a steady value which is determined by the oxygen content of the char, but apparently by a different mechanism, as the loss in oxygen in this instance was very small.

Oxygen attached to carbon atoms has a considerable activating effect, but to date the oxygen groupings responsible have not been identified.

(iii) *Investigations of Pore Structure in Coals and Chars.*—A mercury porosimeter has been constructed and used to investigate the pore structure of brown coal briquettes. The aim is to correlate the pore structure with briquetting variables such as applied pressure, moisture content, and size distribution, and it is hoped that the results will enable the mechanism of binding in briquettes to be elucidated.

For accurate determination of the pore structure by this method, it is necessary to know the advancing contact angle between the mercury interface and the internal pore surface. A method of measuring this angle directly has been devised and the results indicate that values assumed by previous workers for a regular cylindrical pore model are inaccurate. Experimental measurements of the advancing contact angle for the penetration by mercury of model pores of irregular cross section (i.e. containing re-entrant angles) have given anomalous results which have not yet been reconciled with theory.

(iv) *Gas Chromatography.*—A gas chromatography unit has been constructed for the analysis of fuel gas mixtures and has proved most successful. This is due mainly to the development of a highly sensitive detection cell of the thermal conductivity type using glass-coated thermistors, and to a high degree of temperature control over the silica gel column and auxiliary equipment.

(v) *Brown Coal Ash.*—With the support and collaboration of the State Electricity Commission of Victoria, the Gas and Fuel Corporation, and Australian Paper Manufacturers Limited, a detailed investigation of the nature and behaviour of the ash from Victorian brown coals has been initiated in the Cement and Ceramics section. The aim of the project is to define the conditions which may promote fusion and agglomeration of the ash during combustion of these coals.

XX. PHYSICAL METALLURGY.

1. General.

The Section of Physical Metallurgy is a small research group at the Melbourne University Research School of Metallurgy, established by the Organization in co-operation with the University. The Section confines its research to specialized projects in the field of metallurgy, e.g. titanium and metal deformation. The work of the Section is described in this Chapter. Work on metal physics is in progress within the Division of Tribophysics (see Chapter XXI.). The work of the Division of Industrial Chemistry on foundry sands is reported in Chapter XVII., Section 4.

Section of Physical Metallurgy.—The research of the Section has continued on the projects described in the previous annual report.

Members of the Section have continued to assist the University in the supervision of post-graduate students and have again organized post-graduate discussion groups. The Section continues to receive and answer many enquiries from industry concerning metallurgical problems.

2. Titanium and its Alloys.

(Section of Physical Metallurgy.)

Measurements have continued of internal friction and rigidity modulus in super-purity titanium, iodide-refined titanium, and alloys of iodide-refined titanium with oxygen, nitrogen, aluminium, and zirconium. These observations have been explained in terms of current models of crystal structure and have indicated some interesting properties of the titanium lattice.

3. Deformation.

(Section of Physical Metallurgy.)

A new hypothesis concerning the mechanism of boundary migration during creep has resulted from further work on grain growth during creep and annealing of lead. An etching technique has been developed to examine lead with polarized light, and so reveal orientations of grains as colour contrast.

Large lead bi-crystals of controlled orientation have been grown *in vacuo* and creep specimens cut from them chemically. Creep tests are in progress and study the effect of stress, orientation difference, temperature, and presence of substructure on the amount and mode of deformation, especially at the grain boundary itself.

The construction of the X-ray microbeam set has been completed and it has been successfully operated. The equipment has been calibrated and the spot size on the target measured and found to be approximately 40μ. Preliminary work using the equipment to produce X-ray micrographs has been completed.

4. Analytical Methods.

(Section of Physical Metallurgy.)

Methods have been developed for the estimation of traces of impurities in lead. A study has been made of the estimation of small amounts of tin in ores and metallurgical products. This has been used in experiments on the extraction of tin by pressure leaching methods.

XXI. TRIBOPHYSICS.

1. General.

Tribophysics means literally—" rubbing physics "—that is, the physics of friction. The Division of Tribophysics had its origin early in World War II. as a group studying wartime problems of friction and lubrication. The original investigations of the Division have been continued and extended to include fundamental studies in metal physics, surface physics, and the chemistry of solids. The work of the Division of Tribophysics is described in this chapter.

Division of Tribophysics.—The work of the Division has been continued along the general lines described in the last annual report. There have been no changes in senior or administrative staff. The colloquia held with other metallurgical groups continue to be an important medium for the exchange of specialized knowledge.

The co-operative research with the Broken Hill Associated Smelters Proprietary Limited on some fundamental aspects on the refining of lead has continued for most of the year. In particular, the surface properties of liquid lead have been measured in various media by means of a radiographic technique.

2. Properties of Surfaces.

(Division of Tribophysics.)

Work on the physics and chemistry of solid surfaces is concerned mainly with the nature of the surface after preparation by various methods (bombardment with ions; thermal, chemical, and electrolytic polishing and etching) and the effect that these treatments have on adsorption, desorption, and catalytic activity. Most of the experiments are carried out on the surfaces of large single crystals.

(*a*) *Friction of Lubrication of Bearings.*—Work on the factors affecting breakdown of the oil film in sleeve bearings has continued. The emphasis has been on the effect of small geometric errors of the bearing. This has necessitated the development of special equipment for the production of very accurate bores. Finishing cuts are made by a boring bar which is supported by an oil film in the previously semi-finished bore. In this way it is possible to eliminate errors in the bore resulting from previous operations, and to obtain a very good surface finish, limited only by the cutting tool used rather than by errors or lack of rigidity in the machine tool.

(*b*) *The Structure of Solid Surfaces.*—(i) *Sputtering.*—One of the few ways in which a surface can be made extremely clean is by sputtering. This process has been studied in detail on surfaces of single crystals of silver. If the current of bombarding positive ions is sufficiently large, the condition of the surface is principally determined by the energy of the ions and the direction in which they are incident on the crystal. Bombardment with argon ions having energies between 22 eV and 3 keV always disturbs the crystal in a thin zone near the surface. The detailed structure of this surface layer has been derived from electron diffraction patterns. It has been shown that dislocations are generated by ions striking the surface. These dislocations associate in such a manner as to rotate small blocks of the crystal. These rotations are mostly less than 10-15° but can be much larger.

If an alloy is being sputtered, a change in composition occurs in a thin surface layer. Electron diffraction patterns show that the minimum energy of the bombardment ion needed to remove a metal atom from the surface is extremely low (a few electron volts).

(ii) *Thermal Etching.*—The production of fine ridges on the surface of silver when it is heated in air for several hours near its melting point has been explained in terms of the differences in surface energy between different crystal planes. Studies of the kinetics of this etching process have shown that if an electric gradient is present in the metal during etching, the surface structure produced is profoundly affected by the electric polarity. This suggests that etching proceeds by the movement of charged particles. However, measurements of the evaporation rate of different crystal planes of silver have shown that the rate depends on the orientation, and therefore influences the thermal etching.

(*c*) *Chemical Properties of Surfaces.*—(i) *Adsorption of Long-chain Ions on Crystals.*—The study of the adsorption of dodecyl sulphate on barium sulphate was continued. Convincing evidence has now been obtained from changes in conductivity of the supernatant solution for the adsorption of two layers of ions at saturation. The first layer, in which the long-chain ions are attached through their ionic groups, is adsorbed by exchange with sulphate ions in the barium sulphate surface. In the second layer, however, the dodecyl sulphate ions are adsorbed "amphipathically" with their hydrocarbon chains directed towards the crystal surface. The second layer, therefore, counteracts the hydrophobic properties of the first layer so that at high concentrations of detergent the surface is always wettable.

The inhibition of flotation of minerals when too high a concentration of collector is used is an example of this phenomenon.

(ii) *Thermal Desorption of Stearic Acid from Silver.*—A polar molecule within a monolayer adsorbed on a solid surface is attached to the surface through the polar group, and to neighbouring molecules in the monolayer by cohesive forces which are generally weaker than the polar forces. For a large paraffinic molecule the mechanism of desorption is determined partly by this cohesive energy, and partly by the polar binding energy. An investigation into the thermal desorption of stearic acid from a close-packed monolayer adsorbed on silver crystals gives information on the relative magnitudes of these two types of binding. For this investigation monolayers of radioactive stearic acid are deposited by the Langmuir-Blodgett technique on single crystals and large-grained polycrystals of silver whose surfaces have been electropolished and sputtered. Results have shown that the rates of thermal desorption of stearic acid from these surfaces depends on the crystal orientation. The degree of anisotropy observed varies with the method of preparation of the silver surface.

(iii) *Catalysis on Single Crystals of Silver.*—The nature of a surface depends on the way in which it has been prepared and treated, and this has a pronounced effect on its catalytic activity. Surfaces can be cleaned by bombardment with positive ions; however, at the same time, this treatment alters the structure of the surface, as has been observed on electron diffraction patterns. It has been found that the rate of the catalytic decomposition of formic acid on a silver surface is increased on bombardment by a factor of up to 100. The results suggest that the reaction occurs on specific sites and that these can be identified with the points of emergence of dislocations. If the frequency factor of the Arrhenius equation is taken as indicating the number of the sites, this number depends on the energy of the bombarding ions and the orientation of the silver crystal.

3. METAL PHYSICS.

(Division of Tribophysics.)

The final aim of this work is to design a material of specified properties and thereby widen the range of materials available to industry. To this end the nature of strength and the mechanism of plastic deformation have to be understood better than they are now.

The forces holding the atoms together in a metal crystal lead us to expect a strength about 1,000 times larger than that usually observed. The reason for the low strength is that most crystals are imperfect, i.e. they contain various types of defects. Whereas the existence of such defects was for a long time inferred from much circumstantial evidence, direct evidence is now available both for their existence and for their role in lowering the strength and making plastic deformation possible. From the practical point of view locking of the defects seems a promising way of achieving greater strength, as the movement of defects is the mechanism of plastic deformation. During deformation the defects multiply and there are about 10^5 times more defects present after heavy deformation than in the fully annealed material.

The types of defects occurring in deformed metals are dislocations (displacements of atomic planes in a vernier-like fashion), vacancies (atoms missing from the orderly array in a crystal), interstitial atoms (extra atoms in the crystal), and stacking faults (extended dislocations). The behaviour of crystals in general, and particularly the hardening due to plastic deformation, is largely influenced by the interaction of defects with each other as this inhibits their movement. In order to understand the origin of work hardening, one has to know the type, the number, and the arrangement of defects in plastically deformed crystals. The determination of these three unknowns is difficult because of the large number of possible combinations, and no one type of measurement alone can yield the solution of the problem. One has therefore to measure as many properties as possible on the same material, and preferably on the same specimen, in order to draw valid conclusions from the correlation of all these measurements. The properties determined in these investigations are the internal energy, density, electrical resistivity, hardness, shape of X-ray diffration lines, and, quite recently, shape of lines obtained in nuclear magnetic resonance.

(*a*) *Properties of Dislocations.*—Detailed correlation of the changes in energy and density accompanying the annealing of deformed copper indicates that the change of density due to a dislocation is equivalent to that caused by two rows of vacancies of the same length.

For copper and nickel the measured change in electrical resistivity is approximately 60 times greater than would be expected from theoretical estimates of the scattering due to an isolated dislocation. This discrepancy is revealed when the stored energy measurements are used to give the density of dislocations in these metals. The possibility that the discrepancy may be due to scattering from stacking faults, associated with the dislocations in copper and nickel, is being checked by comparing the energy and resistivity changes accompanying the annealing of deformed aluminium in which the dislocations have no associated faults.

(*b*) *Point Defects.*—Recent measurements of the energy released from quenched specimens of nickel have shown a release of energy in the same range of temperatures as that associated with the annealing of vacancies in deformed specimens. This provides further evidence for the creation of vacancies during plastic deformation.

Theory indicates that interstitials and vacancies should be created in approximately equal numbers during plastic deformation. Although the evidence for the creation of vacancies is very strong, little experimental data are available for the existence of interstitial atoms. The results of stored energy, density, and resistivity measurements on deformed specimens and on quenched specimens of nickel of various purities are being compared in order to elucidate the role of vacancies and interstitials in deformed metals.

(*c*) *Stacking Faults.*—In the previous Report work on α brass designed to throw light on the role of stacking faults in the plastic deformation and annealing of metals was described. Further work indicates that in deformed α brass the role of stacking faults is partially masked by contributions from point defects, dislocations, and short range order. These respective contributions are being investigated by comparing the results of measurements of stored energy, density, electrical resistivity, hardness, and lattice parameter for deformed specimens with those for quenched specimens.

(*d*) *Interaction of Dislocations with Solute Atoms.*—The motion of dislocations during deformation and recovery processes is hindered when solute atoms segregate to them so as to form " atmospheres ". In previous Reports this phenomenon has been illustrated by the marked influence of purity on the manner in which stored energy is released from copper. By courtesy of the Mond Nickel Co. of Great Britain, samples of nickel of varying degrees of purity are being investigated, and it is found that, as for copper, the purity of the metal is extremely important in determining the manner of release of stored energy.

(*e*) *Grain Size.*—The influence of grain size on the energy stored and on the mechanical properties of copper has been investigated in detail. At low strains far more energy is stored in fine-grained than in coarse-grained specimens, the mechanical properties are superior in the fine-grained material, and the recrystallization temperature is lower. However, at high strains, although the stored energy and mechanical properties become the same for fine-grained and coarse-grained specimens, the fine-grained specimens still recrystallize at a lower temperature than the coarse-grained. With the exception of the recrystallization temperatures, the results elucidate the plastic behaviour of polycrystalline aggregates.

(*f*) *Structure of Deformed Metals.*—Measurements of the diffraction pattern of nickel deformed by compression have been made after annealing to various temperatures. The results indicate that, as for filings, no change in background level occurs during the annealing. The integrated intensity of the lines remains unchanged until recrystallization occurs, when a large decrease in integrated intensity takes place. This decrease is probably due to the presence, after recrystallization, of comparatively large volumes of " perfect crystal " which give rise to extinction effects.

A new electromagnet for high-resolution work has been installed for using nuclear magnetic resonance techniques in the study of the structure of solids.

XXII. NATIONAL STANDARDS LABORATORY.

(*a*) *Standards, Weights, and Measures.*—The National Standards Laboratory, consisting of the Divisions of Metrology, Physics, and Electrotechnology, is responsible for the maintenance of the Commonwealth standards of measurement and for the calibration of precision measuring equipment in terms of those standards (see Chapters XXIII., XXIV., and XXV., respectively).

The *Commonwealth Weights and Measures (National Standards) Act* 1948 provides for the several States of the Commonwealth to continue to administer under State Acts matters relating to weights and measures in trade and commerce. The Organization is responsible for the Commonwealth standards of measurement.

(*b*) *Report of Advisory Council Committee.*—In November, 1957, an Advisory Council Committee, representative of industry and science and including Dr. A. V. Astin, Director of the United States National Bureau of Standards, met and reported on the future development of the Laboratory. The Committee's findings may be summarized as follows:—

(i) Within the present limitations of staff, equipment, and accommodation the National Standards Laboratory is carrying out its standards functions at a high level of efficiency.

(ii) As a result of the limitations of staff and accommodation the Laboratory is unable to make the progress demanded by the rapid development of industry and science, and consideration must be given to adding new activities and responsibilities to the institution.

(iii) A well-planned programme of research complementary to the standards functions is essential.

(iv) Plans for the future should envisage another site of large extent with ample provision for field experiments and for expansion over a long period.

(v) There is need to develop more facilities for providing industry throughout Australia with a testing and calibration service. For this the Laboratory requires more facilities and staff to calibrate the reference standards of laboratories registered by the National Association of Testing Authorities.

(vi) There is need for a director responsible for policy and administration to co-ordinate Laboratory activities and to encourage a wider interest in the Laboratory by Australian industry.

(*c*) *International Co-operation.*—During the year the Laboratory maintained close liaison with the Bureau International des Poids et Mesures and with other national standards laboratories, both by visits of officers and by participation with other laboratories in programmes of precision measurement.

XXIII. METROLOGY.

1. General.

The past decade has witnessed a very rapid increase in the manufacturing and engineering industries in Australia. Accurate measurement is thus assuming an increasing importance in these fields of productivity. Equipment for this purpose must be regularly calibrated against appropriate working standards. These in turn require periodical calibration in terms of the national and international standards.

The work of the Division of Metrology which maintains some of the national standards of measurement is described in this chapter.

Division of Metrology.—The work of the Division has continued along the lines described in previous reports.

Increased demands on the calibration service offered by the Division have necessitated the recruitment and training of additional staff for the calibrating of testing machines.

Two senior members of the staff visited national laboratories overseas and took part in conferences such as the International Standards Organization. The Division assisted the Bureau International des Poids et Mesures in an international investigation into the accuracy to be obtained in the measurement of the length and coefficient of expansion of survey tapes.

A one-day conference on production engineering research was originated during the year and was attended by representatives of industry and Government Departments from various States. A summer school on geometric analysis of engineering designs was held for University and Technical College lectures (see Section 4 (*c*) of this Chapter).

A metrology exhibition held by the Division was well attended by large numbers from the scientific and technical community.

2. LENGTHS AND ASSOCIATED QUANTITIES.

(Division of Metrology.)

(*a*) *Standards.*—(i) *Line Standards.*—One of the Division's metre line standards, made of nickel, has been repolished and regraduated by the latest techniques, and has been calibrated at the Bureau International des Poids et Mesures. Intercomparison of this standard with the Laboratory's other reference metre and yard standards has established reasonably reliable growth rates for all of these standards.

Some progress has been made with improvements to the measuring equipment used in this work.

(ii) *End Standards.*—The maintenance of the Division's reference and working end standards has continued and improvements have been made to equipment and techniques associated with this work.

(iii) *Surveying Tapes.*—Recalibration of the Division's reference tapes has been completed and the tapes appear to be satisfactorily stable.

The Division was invited by the Bureau International des Poids et Mesures to take part in an international investigation into the accuracy to be obtained in the measurement of the length and coefficient of expansion of survey tapes. Results obtained by the Division were in good agreement with those obtained by the other countries taking part.

Progress with the four-metre line standard comparator has been retarded owing to other commitments on the Division's workshop facilities.

(iv) *Length Interferometry.*—The design of apparatus for measuring a one-metre line standard by light waves is well advanced in the Drawing Office. Both static and dynamic measurement is planned, and fringe counting equipment is being developed by the Electronics Section.

The one-metre end standard interferometer is in the hands of the workshop.

(v) *Light Sources and Wavelength Standards.*—Progress has been made with the performance of the variable-gap Fabry-Pérot interferometer with electrical controls on the plates. Spectographic equipment is being obtained for accurate wavelength measurement and line profile studies.

(*b*) *General Interferometry Studies and Associate Research.*—The studies on the effects of obliquity in interferometers and interference microscopes have been completed and have been the subject matter of several published papers.

The study of the phase change at reflection on metal surfaces is being continued, and equipment is being designed for very accurate measurement of two-beam fringe displacements by photoelectric means.

Advice and assistance have been given on interference microscopy, deposition of thin films, and the flatness of a considerable number of optical flats has been tested.

(i) *Thin Films.*—The phase dispersion characteristics of multi-layer dielectric films have been studied by theoretical and experimental methods and the results have been prepared for publication.

A large number of metallic coatings have been prepared for graticules, and a wide range of coatings covering dielectric, bismuth oxide, and metal films have been produced for the Division, other Divisions, and outside bodies.

(*c*) *Engineering Metrology.*—(i) *General Measurement and Consultative Service.*—The number and variety of measuring tools, instruments, gauges, machine tools, and components examined on behalf of other Departments and industrial organizations have increased. A major project in this field has been the assistance given to the Small Arms Factory, Lithgow, in relation to the gauging programme for the 7.62 mm. rifle.

Industry has shown an increased awareness of the need for precision measurement and the Division has advised on a wide variety of measurement problems.

(ii) *Gears and Gear Hobbing Equipment.*—A gear wheel hobbing machine and test gears together with a number of large marine turbine reduction gears have been examined on behalf of the Department of Defence Production.

A portable instrument for the accurate measurement of adjacent pitch errors of large gears has been designed and constructed in the Division.

A number of other types of gears have been examined; in all cases the assistance of the Division was sought as a result of failure in service or difficulties in assembly.

(iii) *Air Gauging.*—A new development in this field has been a measuring unit suitable for the continuous gauging of certain sheet material during production; this work was undertaken on behalf of an industrial organization. An experimental unit is undergoing factory trials.

The special equipment associated with a research project for the Division of Physics has been completed and is now in use.

Some measurements employing air gauging techniques were undertaken on behalf of the Australian Atomic Energy Commission.

(iv) *Screw Threads.*—A wide variety of screw gauges and threaded components have been examined. A number of taper threaded gauges made to the specifications of the American Petroleum Institute have been examined on behalf of an overseas industrial organization.

(v) *Dividing Engines.*—Both the linear and circular dividing engines have been used to produce a variety of scales for National Standards Laboratory projects; the circular engine has also been used as a measuring instrument for angular measurement at radii of the order of 20 in.

(vi) *Equipment and Design.*—Designs have been completed of a number of new items of equipment and of improvements to existing equipment. Manufacture of this equipment has been disappointingly slow owing to the high loading on existing workshop facilities.

(vii) *Lapping Investigations.*—The work mentioned in the previous report on the sharpening of microtome knives has been completed. The equipment and technique developed for sharpening these knives enable this work to be done by comparatively unskilled operators in less time than is required by skilled operators using conventional methods. The apparatus is being made commercially and instruction in its use was given to two groups of histological technicians from institutions where the method has been adopted. The main feature of the apparatus is the subject of a patent application.

Following a request from the Blood Transfusion Service of the Red Cross Society, a satisfactory method for sharpening hypodermic needles was developed in collaboration with the Society. The prototype equipment provides for the sharpening of needles in batches of six and the time required per needle is not more than 20 sec.

3. MASS AND ASSOCIATED QUANTITIES.

(Division of Metrology.)

(*a*) *Standards of Mass.*—The intercomparison of the Laboratory reference standards of mass has been continued, values having now been obtained for all standards down to 10 milligrams.

The special balance, which was ordered for use in the maintenance of the Australian national standard of mass, has been received, and preparations for its installation are in hand.

A 1 lb. weight of stainless steel was verified to a special order of accuracy for the Dominion Physical Laboratory, New Zealand.

(*b*) *Barometer Calibration.*—The design of a primary reference standard barometer has been completed. A more compact version of the electronic pressure controller at present in use is being constructed. No major design changes have been made, but the new instrument should give greater convenience in use.

(*c*) *Density Measurement.*—Special equipment has been installed for the routine calibration of hydrometers. The volume of this work has undergone a steady increase and it now occupies almost the full working time of the present equipment.

An investigation into the density of germanium has revealed a discrepancy between measurements made during the year on a large single crystal and similar measurements made some twelve months previously on another crystal. The cause of the discrepancy is being sought.

(*d*) *Photogrammetry.*—Additions to the calibration facilities were made to enable two cameras of the so-called distortion-free type to be calibrated for the South Australian Department of Lands. It is expected that further calibrations of this type of camera will be required as it is being adopted also by other State mapping authorities.

(*e*) *Time-interval Measurement.*—The high-stability portable frequency standard was put into continuous operation during the year.

The final design of equipment for the routine measurement of geometric errors in watches was commenced.

Equipment is being assembled for a photographic method of rating time-of-day watches.

(*f*) *Measurement of Fluid Flow.*—Requests for this type of work were again received from various industries and were dealt with wherever possible, and a gas-velocity measuring instrument was obtained to assist in some of this work.

(*g*) *Volumetric Glassware.*—Included in the large quantity of test work which was dealt with in this field were a number of items for use as standards by the Weights and Measures Section of the Tasmanian Department of Labour and Industry.

4. Applied Mechanics.

(Division of Metrology.)

Requests for advice and assistance in vibration problems have again been numerous. To divert some of this load, a survey is being made of consulting engineers and others who may undertake this work.

(*a*) *Measurement of the Physical Quantities.*—(i) *Force.*—Consideration was again given to the provision of the equipment required for the calibration of portable load measuring devices such as proving rings and standardizing boxes.

(ii) *Hardness.*—A report on a method of measuring an indenter force of 1 kg. has been prepared, and some experiments have been made on the new-type 150-kg. single proving lever for the measurement of indenter force.

(iii) *Impact.*—The apparatus constructed during the previous year has been used satisfactorily in the calibration of impact testing machines in industry.

Further investigation into possible errors in impact testing machines is proceeding.

(*b*) *Vibration.*—(i) *Vibration Isolation.*—The main project has been the study of seismic mountings for equipment. A theoretical analysis was made, followed by experimental work involving the examination of machine tools installed on large seismic mountings designed by various firms in consultation with the Division. A report was completed on the large roll-grinder mounting (120 tons seismic mass) referred to in the last Annual Report, and the test results were consistent with the theory. A new mounting (50 tons seismic mass) for a gear grinding machine installed at the Ordinance Factory at Bendigo for producing the extremely accurate gears required in marine turbines has recently been examined for the Department of Defence Production.

Load/deflection tests were made on a batch of isolators of the type used in the above mountings, and some consideration was given to the possible effects of their observed non-linearity on the performance of the mountings.

Performance tests on the smaller Haringx-type vibration isolating table have been completed both in controlled vibration tests and in service.

A survey to 1954 of the literature on vibration and shock isolation (N.S.L. Tech. Pap. No. 7) was widely distributed and is now out of print. In response to the continued demand, the survey was completely revised and brought up-to-date, and will be published soon in the same series.

(ii) *Vibration Measurement.*—Some further work has been done on the development of capacity-type vibration transducers. A protoype for a miniature air-gap capacity transducer with acceleration response is being made. A considerable amount of *ad hoc* vibration measurement work has been done during the year. One important undertaking was the measurement of the vibration characteristics of gear-boxes for the main propulsion machinery in Australian warships for the Navy Department.

A prototype adjustable-resonance calibrating table has been made for calibrating the smaller accelerometer-type transducers and promises to be very satisfactory in the frequency range up to about 150 cycle/sec.

Many demands for vibration services have been satisfied and numerous enquiries answered. These have reduced progress on research projects.

(iii) *Dynamic Balancing.*—Calibration services have been given to the Navy Department in the examination of dynamic balancing machines and to industry in dynamic balancing in general.

(*c*) *Engineering Design Analysis.*—(i) *Design Techniques.*—As in the previous year the emphasis has been on the teaching of this subject. A series of lectures was given throughout the third term of 1957 to fourth-year engineering students of the University of Sydney.

The Division held a summer school on " Geometric Analysis of Engineering Designs " early in February, 1958. The course occupied a week of lectures and tutorial periods and was designed to assist University and Technical College lecturers in their teaching of the subject in degree and diploma courses. A total of ten lecturers attended from New South Wales, Victoria, South Australia, Western Australia, and Tasmania.

Work is continuing on the preparation of papers and additional problems to illustrate the application of the principles of engineering design analysis.

Some of the Division's work was submitted for the consideration of the American-British-Canadian Conference on Drawing Practice held in Toronto in October, 1957.

(ii) *Process Variability.*—A paper has now been published on the investigation into the relative performance of the British and American types of " NOT GO " screw plug gauges for unified threads.

A paper has been prepared on the techniques of dimensional analysis of production processes; this technique is now being tested in practice.

Further work has been done on the tapping of nuts on bent-shank, automatic tapping machines. Industrial firms have co-operated in this work by supplying taps, by the loan of a quarter-inch bent-shank automatic tapping machine for use in the Laboratory, and by incorporating the Division's special experiments into the normal production of their factories.

(iii) *General.*—Accurate knowledge of the tool geometry used in machining, and in particular in process variability studies, is essential, and the small metrology group within the Section has throughout the year been developing various techniques for such measurements. These have been applied to the large numbers of tools used in the research investigations, including turning and boring tools, taps, spade drills, gun drills, twist drills, and the like.

A successful investigation was conducted for an engineering firm on the correct tool geometry and cutting conditions for machining certain aluminium alloys.

(*d*) *Machining Research.*—(i) *Machinability of Australian Materials.*—The investigation into the machinability of Australian-made materials has continued and considerable experimentation has been carried out in developing the best techniques. In pursuing this work, the Division has collaborated closely with Broken Hill Proprietary Company Limited, who have assisted by supplying the material and by seconding an officer to work with officers of the Division in carrying out the tests.

Work has also proceeded on the relation between microstructure and the machinability of steels, and a paper has been published describing a particular experiment carried out on SAE 1045 semi-killed steel.

Concurrently with the above investigations, data are being accumulated on accelerated tool-life tests with the object of developing a reliable technique for the rapid determination of machinability.

(ii) *Cutting Tools.*—The design of the Kolesov type of tool has been successfully applied to the special boring tools used for deep hole drilling and boring.

Full-scale investigation is now being conducted with ceramic tools from five different manufacturers. Special tools have been developed in the course of research investigations.

(iii) *Deep Hole Drilling and Boring.*—The investigation into the machining of tractor bushes in SAE 1016 steel has continued along the two lines previously reported.

(iv) *Footrot Cutter.*—A pneumatic cutter has been developed at the request of the McMaster Animal Health Laboratory for the treatment of footrot in sheep. The cutter is designed to replace the hand shears at present used to pare and trim the affected feet. Tests are now being carried out.

(v) *Basic Research in Machining.*—The literature relating to the mechanics of cutting and wear of cutting tools is being surveyed preparatory to commencing research in these fields.

(vi) *General.*—Other projects undertaken throughout the year consist of an investigation on centreless bar turning, some tests on the machinability of aluminium alloys, and free-cutting brass and the use of carbon dioxide in drilling. In conjunction with the Electronics Section, a special multi-channel recording instrument is being developed for use with a strain gauge dynamometer for measuring tool forces. Advice was given on a number of machining topics in reply to inquiries from industry.

XXIV. PHYSICS.

1. General.

Physics is one of the basic scientific disciplines, and the techniques of physics are essential in varying degrees to all the other sciences. Work in physics is undertaken in all the laboratories of the Organization, but the Division which is responsible for the maintenance of the Commonwealth standards of measurement in heat and light is the Division of Physics—an integral part of the National Standards Laboratory in Sydney. In its Heat Section the Division also studies both theoretically and experimentally the properties of materials at very low temperatures and in its Light Section studies solar phenomena.

This Chapter describes the work of the Division of Physics. The Division's work in solar physics is described in Chapter XXVIII., Section 2.

Division of Physics.—The research programmes of the Division have continued in the general pattern of previous years, and there have been no new major projects initiated; nor during the year have there been any changes in senior or administrative staff.

During the year, Dr. R. G. Giovanelli, the leader of the Light Section, visited laboratories overseas and attended conferences in Great Britain, Europe, and North America.

Lectures on photometry and colorimetry have been given during the year, including a post-graduate course entitled: " Physical Aspects of Colour and Colour Measurement ", given in collaboration with the New South Wales University of Technology. Lectures were given as part of the " Winter School of Microscopy " at the University of Sydney.

In the Heat Section, the amount of equipment calibrated has been greater than in any previous year, and there have also been more requests from industry and scientific establishments for assistance in the solution of problems.

The Division has undertaken its programme of observations as part of Australia's contribution to the International Geophysical Year.

2. Heat.

(Division of Physics.)

The principal fields of work in heat are temperature measurement, hygrometry, viscometry, and low temperature physics. Research and developmental work is in progress in each of these and is mainly directed towards the improvement of standards of measurement, and the development of new or better methods of measurement and control, or to more fundamental investigations.

(*a*) *Measurement and Control of Temperature.*—(i) *International Temperature Scale.*—The need for a uniform and accurate means of measuring temperature has long been recognized by the specification of an International Temperature Scale. The improvement of this scale, its extension beyond its present range, and an increase in accuracy of temperature measurement generally are among the aims of standards laboratories.

During the year the accuracy of the Laboratory's realization of the Scale at high temperatures has been considerably increased and proposals have been formulated for its extension to well below the present lower limit of —183° C., based on an investigation of the temperature dependence of the electrical resistance of platinum. The scale above 1,063° C. has been intercompared with that of the National Physical Laboratory, England.

The suitability of the melting points of certain metals for use as primary or secondary fixed points is being investigated, and limitations in the accuracy of platinum thermometers are being examined.

(ii) *Thermometry and Pyrometry.*—As in previous years advice has been given or, where desirable, investigations have been made, on many scientific and industrial problems in temperature measurement and control. More than 60 industrial installations for heat treatment have been tested and more than 400 temperature measuring instruments calibrated.

(iii) *Temperature Control.*—Equipment designed in the Division for use in the lowering and control of human body temperatures for surgical purposes (hypothermia) is now in routine use in two hospitals for cerebral and heart surgery.

(*b*) *Hygrometry.*—Activities in this field have included the maintenance and extension of standards facilities, the testing of a wide range of hygrometers, the solution of special problems for industry, and the further development of hygrometric techniques.

(i) *Electrolytic Condensation Hygrometer.*—This new type of hygrometer, which makes use of a single crystal of a water-soluble ionic substance in a miniature isothermal enclosure, is able to provide a very rapid response and exceptionally high accuracy. Its characteristics have aroused much interest both locally and overseas.

A prototype instrument to the Division's design has been made by a local firm with a view to commercial production. Other instruments, designed to be suitable for use as Laboratory standards for humidity measurement, are nearing completion.

A survey has been made of salts likely to be particularly suited for use as crystal elements. In the course of this work a method has been developed for measuring the relevant eutectic temperatures of very small quantities of material.

(ii) *Probe Hygrometer.*—A technique suitable for measurements at sharply located points has been developed which makes use of a simple and reliable calibrator unit together with small probes of rapid response and good short-term stability. The probes are connected to an electronic indicator which has been redesigned to provide a linear relative humidity scale adjustable for individual probe calibrations.

(iii) *Moisture Content of Very Dry Gases.*—The moisture content of a gas which is nominally dry at atmospheric pressure is often measured by determining its frost point at high pressure, where deviations of water vapour density from perfect gas behaviour may amount to as much as 50 per cent. Measurements at atmospheric pressure with a two-stage physical absorption method are in good agreement with values computed from high pressure measurements using published virial and interaction coefficients, and have confirmed the practical possibility of obtaining accurate results by using the electrolytic condensation hygrometer on the highly compressed gas.

(*c*) *Viscometry.*—The standard procedures for viscometric measurements make considerable use of transfer liquids, which are subjected to measurement at one rate of shear and then used at another to build up the viscosity scale. These procedures at present suffer from serious limitations due to the kinetic energy correction of conventional capillary viscometers and uncertainty as to the effect of rate of shear. A new and simple form of capillary viscometer developed in the Division eliminates the kinetic energy term and enables the effect of shear rate to be determined precisely.

(*d*) *Low Temperature Physics.*—(i) *Low Temperature Research Facilities.*—The helium liquefier has continued to operate very satisfactorily and to meet all calls made on it. An air liquefier, recently installed, has proved of great value and has supplied all the requirements (about 10,000 litres per year) of the National Standards and Radiophysics Laboratories.

(ii) *Conduction Phenomena in Solids.*—Studies of the basic structure of metals and alloys from measurements of their electrical and thermal conductivities over a wide range of temperatures have been continued. These have included the investigation of the mutual interactions between electrons, lattice vibrations and lattice imperfections in the transition metals iron and rhodium and in alloys of gold with platinum and chromium, and the study of the nature and concentration of the lattice imperfections in gold alloys and alpha brasses. The latter investigations have been particularly related to the effects of plastic deformation and annealing.

Additional information about the interaction phenomena can be obtained from the thermoelectric forces, measurements of which will be commenced shortly. For this an amplifier is under construction which should be capable of measuring 10^{-11}V.

(iii) *Paramagnetic Resonance.*—Studies of the internal forces in crystalline solids containing paramagnetic material, from measurements of the frequencies at which microwave radiation is absorbed in the presence of a magnetic field, have been considerably extended.

Spectrometers for use at 4° K. have been brought into use and research has been undertaken on the interactions between pairs of magnetic spins in a material which is favourable for elucidation of the basic interactions involved.

Paramagnetic resonance phenomena have been utilized elsewhere in the design of a microwave amplifier (" maser ") of remarkable sensitivity—a development of immense importance in both pure and applied science. Co-operative work with the Divisions of Radiophysics and Electrotechnology has been commenced which is directed towards the development of a similar amplifier and preparations are being made for measurements on the relaxation processes which are fundamental to maser action.

(iv) *Temperature Measurement.*—As part of the investigation of the electrical resistance of platinum a number of platinum thermometers have been calibrated down to 14° K. for use as substandards in the calibration of carbon resistance thermometers; thus improved accuracy for specific heat measurements is provided.

Preliminary investigations have been made on the use of a particular type of nuclear resonance for temperature measurement down to about 10° K.

The accuracy of temperature measurement in terms of the vapour pressures of liquefied gases has been improved by the development of an optical system for viewing a mercury miniscus with a precision of setting of 0.02 mm.

3. LIGHT.

(Division of Physics.)

The work of the Light Section covers the fields of photometry, optics, and solar physics, some of the work in this latter field being part of Australia's contribution to the International Geophysical Year. The Section is responsible for the maintenance of the various photometric standards of measurement, for undertaking calibrations and precise measurements, and for providing technical guidance in the fields of photometry, colorimetry, and optics. The Section's main research interests are in the optical properties of diffusing media, the quality of optical images, and solar physics.

(*a*) *Photometry.*—Of the numerous photometric tests and calibrations carried out during the year, those most frequently required have been the calibration of lamps and illumination meters, the testing of reflectorized materials and road-sign photometers, the measurement of transmission and reflexion properties of materials for ultraviolet, visible, and infra-red radiation, the measurement of the spectral energy distribution of light sources, the measurement of colour and colour difference, and the calibration of photoelectric haemoglobinometers.

(*b*) *Optics.*—Facilities are maintained for precise measurement of optical properties of materials and the geometrical parameters of lenses. Technical inquiries have been received covering a wide range of problems involving the production or use of optical instruments. One of these problems was the testing and adjustment of a 10-in. diameter telescope objective from the Commonwealth Observatory, Canberra, used in the time service.

(i) *Optical Properties of Diffusing Media.*—The Division has continued its experimental study of the optical properties of opaque diffusing media, particularly those properties which affect the colour. It has been found that the reflectance of pigment suspensions in clear matrices is independent of the pigment concentration except at exceedingly high concentrations; this result is in general agreement with theory. Further experiments have been carried out on the behaviour of pigment mixtures, and it has been shown that, provided the pigment particles are well dispersed, simple isotropic scattering theory permits accurate prediction of the colour.

Whereas the above experiments relate only to opaque diffusers, the behaviour of translucent diffusing layers is also of great practical interest; for example, in the opacity of paint layers. A simple theory of light diffusion, the Kubelka-Munk theory, has been applied to the photometric problems involved in the use of "hiding power boards" to measure paint opacity. It has been shown that such measurements have little meaning unless the boards comply with suitable specifications and a basis for setting up such specifications has been established.

(ii) *Optical Image Quality.*—Investigations have been continued on the theory of image formation in optical systems. Previous work has been concerned chiefly with incoherent illumination. The intermediate case of partially coherent illumination is important in microscopes and projector systems, and new work in the Division has led to a general theory of image formation that is applicable to any degree of coherence. Equipment for assessing the quality of an image by measuring the contrast transfer function of the optical system is under construction.

The performance of an optical system such as a telescope depends on the instrument itself and on the optical uniformity of the light path through the atmosphere. In large astronomical telescopes the intervening atmosphere sets the limit in performance to practical observations. This phenomenon is being investigated theoretically and experimentally, by using as a simplified model of the atmosphere a sinusoidal disturbance.

(iii) *Optical Alignment.*—The problem of alignment is of considerable importance in many fields of engineering. Most methods used are mechanical; even conventional alignment telescopes depend on the mechanical accuracy of construction. However, it has been shown recently elsewhere that precision alignment is possible using a "lens" with a conical surface which, with a point source as object, gives an "image" consisting of a straight line along the axis.

As this "image" is a manifestation of spherical aberration, it would be much simpler to use a lens with spherical surfaces, designed to have sufficient aberration, since such surfaces are much easier to manufacture and test. Theory has shown that the precision to which settings can be made is almost as high for a lens as for a cone, and, with a lens of 3-in. diameter, settings can be made to better than 1 sec. of arc up to distances of over 100 feet.

(*c*) *Solar Physics.*—The work of the Division of Physics on solar physics is described in Chapter XXVIII., Section 2.

4. Electronics.

(Division of Physics.)

This Section renders assistance to the other Sections and is collaborating in the measurement of certain nuclear standards.

Examples of electronic apparatus designed or constructed are—

(a) A photoelectric servo system for the control of a physical balance for the measurement of strong magnetic fields;

(b) a nuclear resonance thermometer using the quadrupole resonance of Cl, and

(c) the control to 1 in 10 of currents up to 10 A in an electromagnet by means of a galvanometer amplifier and power transistors.

XXV. ELECTROTECHNOLOGY.

1. General.

Electrical measurements and electronic instrumentation are playing an ever increasing part in Australian industry and many more firms are now interested in building up their own test and measurement facilities. As an essential part of this instrumentation the Division of Electrotechnology maintains the Commonwealth standards of measurement of electrical quantities. It also maintains the Commonwealth standard of measurement of frequency in conjunction with the Commonwealth Observatory, Mount Stromlo, and other standards derived from frequency, resistance, and electromotive force. The Division undertakes the calibration of clinical instruments and carries out research to improve and extend electrical measuring and standards facilities.

This Chapter reports the work of the Division of Electrotechnology together with that of the Electrical Research Board, established in collaboration with the Electricity Supply Association of Australia to encourage research within the universities (see Section 8).

Division of Electrotechnology.—There has been no major change in the work of the Division during the current year. However, in view of the increasing use of high voltages in Australia for the transmission of electric power, it has become evident that the Division must correspondingly expand its high voltage measuring facilities. With this in mind, Mr. Clothier visited national laboratories overseas to study research and facilities in high voltage measurement.

2. Direct Current.

(Division of Electrotechnology.)

(*a*) *Primary Electrical Standards.*—The electrical units are not arbitrary like the metre, kilogram, and second, but are defined uniquely in terms of them by the laws of electromagnetism. The basic electrical standards must then be pieces of equipment whose electrical properties can be calculated from their dimensions. These calculable standards are then used to calibrate other standards in the more convenient form of resistance coils and standard cells which must be stable enough to preserve the units in the intervals between such absolute determinations.

The work on calculable capacitors (see Section 4 (*a*) (i) of this chapter) will ultimately enable the Division to undertake absolute determination of the ohm. In the meantime it is necessary to rely on check calibrations of a group of coils and cells by other national laboratories.

The resistance coils from the Australian primary group were checked at the National Physical Laboratory, and also enlarged with coils of American manufacture calibrated and selected by the National Bureau of Standards. The resulting intercomparisons have shown that the unit of resistance has been maintained relative to the two overseas standards to within one part in a million.

Standard cells from the primary group were also checked at the National Physical Laboratory, and have shown agreement approaching one part in a million for the units of voltage in the two countries. A number of new cells are under observation so that the most suitable ones can be selected for addition to the primary group.

(*b*) "*Build-up*" *Resistor.*—A report has been received on the special 1-100 ohm "build-up" resistor presented to the International Bureau of Weights and Measures which shows that it has proved very satisfactory for this purpose.

(*c*) *Low Frequency Measurements.*—Many of the problems of precision resistance measurements could be simplified by the use of low frequency alternating current rather than direct current. Equipment has been assembled for the precision measurement of resistance at 4 c/s to test the possibilities of this technique.

(*d*) *Calibration Service.*—The calibration of other laboratories' D.C. reference standards has now grown to such a volume that it is necessary to limit the service strictly to this type of work.

There remains a fairly large unsatisfied public demand for less precise electrical calibrations. In New South Wales in particular the Sydney County Council and the New South Wales Government Railways have been most helpful in trying to satisfy some of this demand.

3. POWER FREQUENCY.

(Division of Electrotechnology.)

(*a*) *Extension of Frequency Range.*—Owing to the increasing application of electrical equipment operating on 400 c/s, 800 c/s, and higher frequencies, attention has been directed towards the problem of testing electrical indicating and measuring instruments at these frequencies. Although a few of the Laboratory's low frequency standards are suitable for use at higher frequencies, in the majority of cases new instruments and modified techniques are found to be necessary. As a first major step an order has been placed for two high-power electronic amplifiers which, together with a driving oscillator, will serve as a power supply for the frequency range from 50 to 5,000 c/s.

(*b*) *Crossed Cylinder Capacitor.*—Various arrangements of crossed cylindrical tubes, one of them carrying a short cylindrical guarded electrode, have been tested for use as three-terminal air capacitors at voltage ratings up to 140 kV. The capacitance value may be obtained from a calibration in terms of the electrode spacing or, if higher accuracy is necessary, from a bridge measurement taken immediately before use.

(*c*) *Chopped Wave Sphere Gap.*—The addition of a sphere and resistor to a conventional measuring sphere gap has enabled the latter to be used for the controlled chopping of a standard impulse wave.

(*d*) *Evaporation Plant.*—A small vacuum evaporation plant has been set up in order to supply a variety of needs arising in the development of special instruments such as the calculable capacitor and the new standard electrostatic voltmeter.

4. AUDIO AND RADIO FREQUENCY.

(Division of Electrotechnology.)

(*a*) *Calculable Capacitor and Absolute Determination of the Ohm.*—(i) *The Capacitor.*—The calculable capacitor has now reached an advanced stage of development. It is in the form of four insulated cylindrical bars mounted vertically and parallel to each other in an external cylindrical shield, the effective length being determined by the end separation of two metal shield tubes inserted along the axis of symmetry. The capacitance value defined by the standard is the capacitance change computed from the change in the effective length when the shield tubes are moved along the axis of symmetry. This change is measured directly in wavelengths of the green radiation from an electrodeless mercury 198 isotope lamp with the aid of a Fabry Pérot interferometer mounted in the ends of the shield tubes. The upper tube can be translated vertically along the axis of symmetry through a total travel of about five and a half inches by means of a precise screw. The lower shield tube can be translated vertically through a range of a few wavelengths and can also be tilted in two directions at right angles for fine adjustment of the interferometer plates for parallelism. These adjustments to the lower shield tube are performed electromagnetically. In addition the electromagnetic control is used to impart a small vertical oscillation to the lower shield tube and thus to the optical path difference. A photomultiplier tube detects the corresponding cyclic variations in the intensity of the central fringe, the mean intensity of which can be brought to a maximum by vertical translation of the lower shield tube. In use the shield tubes are varied in separation by an integral number of half wavelengths, the initial and final positions being located at intensity maxima for the central fringe. The actual number of half wavelengths in the interval is determined by a build-up procedure.

The capacitor and interferometer assembly are enclosed in an evacuated chamber in order to eliminate uncertainties in permittivity and refractive index.

It has been confirmed that the bridge sensitivity, with 1000 V on the ¼ pF calculable capacitor, is sufficient to enable changes of capacitance of 1 part in 10^7 to be detected with certainty. The corresponding setting accuracy is approximately 1/20th of a fringe, and this limit has also been reached in the preliminary tests.

(ii) *Associated Equipment and Measuring Techniques.*—A number of very stable components and precision measuring assemblies are necessary to enable the 1-ohm resistance standards to be measured in terms of the calculable capacitor. The development of the very stable capacitors and resistors is proceeding slowly. It is desirable that these should have a low temperature coefficient, and a number of temperature compensated capacitors have been designed. A resistor using bare wire on a glass former has been developed to allow heat treatment of the wire after winding. With a new resistance alloy this permits adjustment both of the resistance itself and of the temperature coefficient.

One of the difficulties of measuring very small capacitors is associated with the finite impedance of the leads connecting the capacitor to the measuring circuit. A new method of connexion has been devised in which this type of error is not a limitation.

Further work on noise in thermionic valve amplifiers has shown that the limiting current sensitivity is set by the finite value of the grid current and the input conductance of the first valve.

(iii) *Theoretical.*—Further theoretical study of the properties of cylindrical cross capacitors has shown that the condition of mechanical symmetry is not necessary. There is a very general relation connecting the two cross capacitances which is valid for all cross sections. If the two cross capacitances are made approximately equal by shifting one of the cylindrical conductors, then the value of the mean capacitance may be computed with very great precision. It has also been proved that asymmetry due to thin dielectric films on the surfaces is reduced to a second-order effect by taking the mean of the two cross capacitances.

(*b*) *Impedance and Attenuation Measurements at Microwave Frequencies.*—Facilities for making impedance and other measurements at microwave frequencies have been set up, chiefly in the 9,000 Mc/s range. The design of a highly stabilized klystron oscillator for this frequency is near completion. Equipment for the precise measurement of attenuation at microwave frequencies is being developed. The standard of attenuation consists of a tube having an accurate and uniform bore. A specially engraved optical scale has been received from England and work is proceeding on the associated electronic equipment.

(*c*) *Frequency Measurements.*—A new unit of the frequency standard is being developed by using an Essen ring crystal as the primary oscillator. A new transistor-controlled oven has been constructed and development of a new oscillator circuit is in hand. It is proposed to construct three of these units.

Further work is being carried out on the microwave frequency measuring equipment, to improve its flexibility and ease of operation, while increasing the stability of the source oscillator.

The Laboratory's facilities for accurate frequency measurement were used for obtaining orbital data on the first two Russian earth satellites by the Doppler shift technique.

(*d*) *Microwave Spectroscopy.*—The hyperfine structure of the microwave spectra of heavy water molecules is being analysed on the high-speed digital computer SILLIAC in an attempt to determine more accurately the electric field gradient at the position of the deuteron nuclei in those molecules and to estimate the magnetic constants which describe the smaller effects observed in the spectra.

Measurements of a number of lines in the $^{34}SO_2$ spectrum have been made and satisfactorily fitted to a semi-rigid rotor model with distortion parameters derived from the force constants of $^{32}SO_2$. A similar set of constants for $^{33}SO_2$, but based on fewer measurements, has also been found.

(*e*) *Random Noise.*—A number of problems involving random voltages in non-linear networks have been investigated. Signal detection circuits and other networks have been studied experimentally, particularly in regard to the probability distributions of their output voltages. Equipment, auxiliary to the electronic probability distribution analyser, has been constructed. This has facilitated automatic measurement procedures and the rapid conversion of experimental results into a form suitable for graphical presentation and calculation.

(*f*) *Impedance Standards for Very High Frequencies.*—The greater use of very high frequencies for services such as television and navigational aids has created a demand for the corresponding basic standards of measurements. One of the most important quantities to be measured is the impedance of the various transmission circuits and components. Impedance standards are under development to provide calibration facilities for the various commercial measuring instruments that are now available. At these frequencies it is not possible to derive precise impedance standards from the 1-ohm resistors maintained at direct current, nor from low frequency standards. The most promising standards are based on the electrical properties of transmission lines calculable from their mechanical dimensions. Precision coaxial lines with high conductivity are being developed for this purpose. The work has been greatly assisted by the use of precise air gauging equipment developed by the Division of Metrology. This equipment measures simultaneously the diameters of the inner and outer conductors of a coaxial line, and indicates directly characteristic impedance.

5. MAGNETIC MEASUREMENTS.

(Division of Electrotechnology.)

Equipment for the routine testing of magnetic materials have been redesigned to make the best use of the special instruments developed in previous years. Two magnetometer elements have been built into a gradient instrument to provide automatic field uniformity control. An extensive investigation has been made of the decade flux linkage generator to enable this instrument to be used to the limit of its accuracy. These and other innovations have been incorporated into the design of a testing console to improve the accuracy and speed of steady-field magnetic testing.

Magnetization curves and hysteresis loops can now be obtained for samples in various forms and in types of material ranging from permanent magnet to high permeability grades and including feebly magnetic samples.

6. DIELECTRICS.

(Division of Electrotechnology.)

(*a*) *Crystal Growing.*—It has become clear that progress in several of the dielectric research investigations depends on the further purification of the compounds involved and on the production of single crystals. Extension of the work on alkali halides requires large single crystals grown under carefully controlled conditions. Single crystals of organic solids are also desirable to obtain further information on the nature of the imperfections responsible for some types of dielectric absorption. Special furnaces have been constructed and some preliminary experiments have been made to determine the conditions of crystal growth most likely to yield satisfactory organic crystals. In addition to these preparations for growing single crystals further studies have been made of the dielectric properties of polycrystalline materials and liquids.

(*b*) *Aliphatic Long-chain Compounds.*—Previous investigations of β-phase long-chain compounds having the dipole near one end of the chain were made chiefly with esters. However, ethers and ketones are simpler types of dipoles and recently a number of methyl ethers and methyl ketones have been studied. The ketones give no dielectric loss, but the ethers give two absorption maxima similar to those previously observed in the methyl esters.

In the course of the work the frequency factors and energies of activation were determined, and compared with other long-chain compounds. The results confirmed that in long-chain compounds the logarithm of the frequency factor gives a linear variation with the activation energy.

With methyl ethers in the α-phase the observed dielectric absorption is much larger than in the β-phase and is approximately equal to the value calculated on the assumption that all of the molecules contribute to the absorption and that the mechanism involves complete reversal of the dipoles. In the γ-phase, crystal defects are apparently not necessary for dielectric absorption to occur.

Investigation of the relationship between crystal imperfections and dielectric absorption in esters has been continued. It has been found that the component of the absorption which is sensitive to plastic deformation may be removed by annealing. The kinetics of the process of removal suggest that it is thermally activated.

(*c*) *Liquid Solutions.*—Debye's relationship between relaxation time, molecular size, and viscosity has not previously been tested under conditions where it might be expected to apply, viz. with large solute molecules in solvents of small molecular size. This was recently investigated in this Laboratory and it was found that, when the solute molecules were between three and five times the volume of the solvent molecules, Debye's equation gave good agreement with the observed relaxation times. For smaller solute molecules better agreement was obtained by using a recent equation derived by Hill, who considers the solvent-solute interaction in some detail.

(*d*) *Superconductivity in Metals.*—Work has been completed on a theory of the superconducting specific heat and transition temperature in multivalent metals based on the harmonic motion of the interacting electron-lattice system.

(*e*) *Dielectric Breakdown.*—A review of theories of dielectric breakdown in alkali halides was prepared. At the request of Professor H. Fröhlich it was later extended to include both experimental and theoretical work. Apparatus has been constructed for experimental work on dielectric breakdown.

(*f*) *Cetyl Alcohol.*—Officers of the Division of Industrial Chemistry have been investigating the physical properties of pellets of impure cetyl alcohol to be used for spreading on reservoirs to prevent evaporation. An important aspect of this work is the change from α- to β-phase which occurs at different temperatures, according to purity. The dielectric properties are very sensitive to the phase change, and in order to help in this programme a series of dielectric measurements were made on twelve different samples of cetyl alcohol at various temperatures, after treatment in various ways.

(*g*) *Plasticizers for Polyvinyl Chloride.*—With the increasing use in Australia of polyvinyl chloride dielectric, a number of firms are now producing di-*iso*-octyl phthalate as a plasticizer in the manufacture of this plastic. Help has been given to several firms to set up their own cells and electrical apparatus for measuring the conductivity of their product, which must be maintained within close limits.

7. Special Investigations.

(Division of Electrotechnology.)

Equipment for Bore Hole Logging.—In the previous year equipment was developed to investigate transmission of information from a probe at the bottom of a string of drilling rods to the surface by using vibrational pulses in the rods. Such a system allows the logging of geophysical drill holes, which may be far from vertical, without using a cable or special rods to insert the probe. In the field trials a Geiger-counter probe was used to study the distribution of γ-radiation in a drill hole. Satisfactory transmission was found to be possible up to a maximum of 2,400 ft. of rod. A provisional patent has been taken out on this system.

8. Electrical Research Board.

The Electrical Research Board was established with the aim of supporting fundamental electrical research in the universities and to assist graduates to undertake post-graduate research. Grants are made for projects suggested and planned by the universities.

The membership of the Board is representative of the Electricity Supply Association of Australia, the universities, and the Organization. The funds of the Board are derived from contributions from member establishments of the Electricity Supply Association of Australia, and grants have been made at various times to most of the universities in the Commonwealth.

Grants made by the Board for the current year include: a grant to the Electrical Engineering Department, University of Tasmania, for a new project on non-linear circuit theory; a grant to the Physics Department, New England University, for the investigations of arc electrode phenomena; a grant to the Electrical Engineering Department, University of Adelaide, to continue the project on network analysers; a grant to the Electrical Engineering Department, University of Sydney, for research on the dynamic stability of alternators; a grant to the Electrical Engineering Department, University of Queensland, for continuation of the project on the protection of electrical plant against lightning.

XXVI. RADIOPHYSICS.

1. General.

The science of electronics is finding increasing application in the modern world. The techniques of radio and radar in particular are widely employed in scientific and industrial fields, and the use of higher frequencies and pulse techniques have provided new research tools of surprising versatility and power.

The Organization's Division of Radiophysics carries out research in those fields in which modern radio techniques have particular application. It is predominantly engaged in a study of cloud and rain physics, and in fundamental research in radio astronomy. Its programme also includes a study of the physics of semiconductors, in particular of transistors, and their applications in electronic circuits; the development of radio aids to aerial navigation; and work on some aspects of the transmission of radio waves.

The Organization's researches on the propagation of radio waves under the direction of the Radio Research Board date back a long way in the history of radio and have contributed much to the understanding of fundamental conditions and processes in the ionosphere. The Board, which was established in 1927, coordinates the researches of a group at the Radio Research Laboratories, with allied investigations in the services, the Postmaster-General's Department, and the universities. It fosters approved projects in the universities where staff and student interest exist. Liaison between the various bodies carrying out research in the radio field and those who make use of the results of this research is facilitated by a Consultative Committee on Radio Research.

The work of the Division of Radiophysics is outlined in Sections 4, 5 and 6 of this Chapter, and in Chapter XXVII., Section 8, and Chapter XXVIII., Section 3. That of the Radio Research Laboratories is described in Section 7 of this Chapter.

Division of Radiophysics.—The Division's investigations into the practicability of increasing rainfall by seeding clouds with silver iodide from the air have advanced a stage further with the initiation of a third large-scale field experiment. This trial, which is being carried out in the Northern Tablelands region of New South Wales, and those already in progress over the Snowy Mountains and in South Australia, are designed to establish reliably to what extent rainfall in typical areas of Australia may be increased by cloud seeding.

During the year the Division took delivery of two new light twin-engined Cessna 310B aircraft which are particularly suitable for experiments of this type.

The highlight in radio astronomy has been finalization of the plans for Australia's giant radio telescope (see Chapter I., Section 13, and Chapter XXVIII., Section 3).

Dr. J. L. Pawsey, Assistant Chief of the Division, attended the twelfth General Assembly of the Union Radio-scientifique Internationale (U.R.S.I.) at Boulder, Colorado, United States of America, in August, 1957, and following this, at the invitation of the Radio Astronomy Panel of the United States National Science Foundation, spent seven months in extended visits and consultations at several radio astronomy centres in the United States of America.

The Division is taking an active part in observations associated with the International Geophysical Year (I.G.Y.).

Radio Research Laboratories.—Two pieces of equipment, provided by the United States National Committee for the I.G.Y., were installed at Camden, and are now fully operational. These are the airglow recorder originally designed at the Central Radio Propagation Laboratory of the Bureau of Standards, Boulder, Colorado, and the back-scatter ionospheric sounder designed at Stanford University, California. An all-sky camera for auroral and sky photography was also installed.

The Chief Officer-in-charge spent two and a half months overseas, leading the Australian delegation to the twelfth U.R.S.I. Assembly at Boulder, Colorado, and presiding over the sessions of the Ionosphere Commission at the Assembly. He also attended the autumn meeting of the Physical Society of London at Harwell, United Kingdom where he presided at a symposium on ionospheric physics.

2. Cloud and Rain Physics.

(Division of Radiophysics.)

This work is reported in Chapter XXVII., Section 8.

3. Radio Astronomy.

(Division of Radiophysics.)

This work is reported in Chapter XXVIII., Section 3.

4. Radio Propagation.

(Division of Radiophysics.)

The Division is represented on the Consultative Committee for Radio Research which brings together the principal organizations in Australia using radio communications and those engaged in radio research, to obtain co-operative action towards the solution of problems arising in the use of radio communications.

Work has continued on the survey of radio noise levels hroughout Australia at the wavelengths used for broadcasting and for high-frequency communication. The calibration of all the equipment is being undertaken both o ensure the accuracy of the observational results and to provide a basis for comparison of data with the results of a world-wide survey of radio noise levels to be undertaken by the Central Radio Propagation Laboratory of the National Bureau of Standards, using a different measuring echnique.

5. Radio Navigation.

(Division of Radiophysics.)

The development has continued of a method for obtainng bearing from existing Distance Measuring Equipment D.M.E.) beacons.

Tests were concluded on the Bearing Measuring Equipment (B.M.E.) installed at Kingsford Smith Airport, Sydney, and in an R.A.A.F. Dakota. Radials were flown to and from the beacon, and the aircraft position was found to be accurate to within ±2° except when near the beacon. Aircraft position was checked by taking vertical photographs.

A number of orbits were flown and these disclosed an error of up to 10° due to lack of symmetry in the pattern radiated by the ground aerial. The ground aerial has been redesigned and the beacon and aircraft equipment rebuilt in a more portable form. Tests will be repeated at Kingsford Smith Airport, Sydney, and then at a less favourable site where errors due to reflections from surrounding hills might be expected.

The Department of Civil Aviation has shown interest in this work, and made available the sum of £15,000 towards the development of prototype B.M.E.

6. Semiconductors and Transistors.

(Division of Radiophysics.)

The basic physical properties of semiconducting materials and techniques for producing them are being studied in relation to the construction of transistors. A complementary aspect of this programme is the application of transistors in electronic circuits.

(*a*) *Semiconductor Physics.*—Research has continued into three aspects of semiconductor physics, and its application to useful electronic devices—

- (i) the purification of semiconductor materials, and the growth of monocrystals;
- (ii) the transport of charge-carriers in semiconductors;
- (iii) the development of junction photo-devices.

A theoretical expression has been derived for the maximum purification obtainable by the zone-refining process, and found to be in good agreement with experiment. Monocrystals of germanium and silicon have been produced as required for experimental work, and some work done on the influence of growth conditions on crystal quality. The silicon monocrystals have all been grown in a large vacuum oven constructed in the Laboratory.

Investigations of transport properties of semiconductors included Hall measurements on thin films, a theoretical investigation of junctions between regions of low and high conductivity, and experiments on "hot" electrons in silicon. Work on semiconductor devices included the development of a metallic contact which is easily applied to germanium and silicon, and the construction of junction photo-position indicators.

(*b*) *Transistor Circuit Development.*—Development is continuing of a transistorized airborne D.M.E. and an experimental model has been test-flown with satisfactory results. This unit weighs 14 lb., occupies a space twenty by five by eight inches, and consumes 40 watts of power. Compared with the existing valve-equipped model in service in all commercial aircraft throughout Australia, the transistor unit weighs only one-third as much, occupies half the space, and consumes one-sixth of the power.

As test-flown the unit was not completely transistorized, two valves being retained in the transmitting oscillator and two thyratrons used to modulate the transmitter. A modulator using power transistors has now been developed to replace the thyratrons. This involves some complex time-delay regulating circuits, and recently developed high-speed high-current switching transistors should be available to perform this function with greater simplicity in the near future.

A Mk. II model with a Veeder-Root counter type of distance indicator is under consideration giving much improved legibility and distance accuracy. This model will provide 48 channels instead of the present 12.

7. Ionosphere.

(Radio Research Laboratories.)

(*a*) *Travelling Disturbances.*—Regular observations have continued for the determination of direction and speed of travel of disturbances in the *F* region. The fixed frequency observations at Sydney, Camden, and Blaxland have been in progress for nine years and the diurnal and seasonal variations clearly established. An interesting new feature is a marked change in the diurnal variation over the last three summers, apparently connected with the sunspot cycle.

Most of the records in the past have been taken in the daytime, as disturbances are then most readily observable, but improvements in technique have enabled the extension of observations over most of the night as well. Phase-path recording has been introduced at night which enables more accurate observation of small height variations to be made.

(*b*) *Back-scatter Sounder.*—This equipment, the gift of the United National Committee for the I.G.Y., was installed at Camden in July, 1957. It is one of twelve instruments which have been built by Stanford for the I.G.Y. and set up in various localities around the world, and is the only one in the southern hemisphere; it operates on three frequencies in the 12, 18, and 30 Mc/s bands.

Back-scatter sounding of the ionosphere is an oblique-incidence pulsed radar method for the study of the regular layers, sporadic *E*, and a variety of irregularities which occur within the ionosphere. Whereas vertical-incidence ionosphere soundings record in considerable detail only those events occurring overhead, scatter-soundings permit surveillance from a single location of a considerable region of the ionosphere, up to 4,000 km. radius from the sounder, though in lesser detail. In addition, scatter-soundings facilitate the study of classes of ionospheric irregularities which by virtue of their shape and distribution in space exhibit marked aspect sensitivity and can be observed only at oblique incidence. After preliminary troubles good records have been regularly obtained since September. Besides making an international contribution to the I.G.Y., this equipment should provide information of the state of the ionosphere over a vast area, and so contribute to both the travelling disturbance programme and the study of ionospheric trapping of cosmic noise.

(*c*) *Airglow.*—For many years it has been considered desirable to include regular observations of airglow in the programme of the Laboratories. Regular experimental study of radiations from oxygen atoms in the ionosphere should throw light on both the liberation and decay of the free electrons and on the movements of gases in the region. Observations have continued with the airglow recorder supplied by the Boulder Laboratories of the Bureau of Standards. Aurorae have been recorded strongly, and the areas of activity delineated.

(*d*) *All-sky Camera.*—This equipment was installed in October, 1957, and photographs of the whole night sky have been taken regularly at five-minute intervals since that time. These record any aurorae which may occur, and in conjunction with cameras at other stations enable positions and heights of aurorae to be deduced.

(*e*) *True Height Distribution of Ionization in the Ionosphere.*—Ionosondes give the " virtual " height of the reflecting region over a range of frequencies. This virtual height is often extremely different from the true height of reflection; for almost all theoretical studies, and for many practical problems, it is necessary or desirable to know the real distribution of ionization with height. Methods of computing these " *N-h* profiles " have been developed overseas; these have usually neglected the effect of the Earth's magnetic field and are cumbersome and often inaccurate. Attention has been given to the accurate computation of such profiles, taking full account of the geomagnetic field, and the SILLIAC computer in the Physics Department of the University of Sydney has been programmed to give results rapidly. Such profiles have been computed for 50 typical Brisbane records.

(*f*) *Theoretical Studies.*—The theory is being studied of the world-wide anomalies of the F_2 region, and of the disturbance variations of this region associated with magnetic storms, of the trapping by the ionosphere of medium-frequency radio waves emanating from sources above the ionosphere, of the origins of the additional traces observed on ionograms at frequencies below the gyro-frequency, and of the propagation ray-paths effective in " whistler " propagation.

XXVII. ATMOSPHERIC PHYSICS.

1. General.

Aviation, agriculture, and other diverse activities make growing demands on our knowledge of the weather. The Organization has established research groups working towards a better understanding of the physics of the atmosphere. This research is aimed not only at improving the forecasting of atmospheric effects, but also at obtaining a more fundamental knowledge of the weather and the processes which control it.

The Organization's major meteorological investigations are undertaken in the Division of Meteorological Physics and are directed not only to improving prediction but also to using the science of meteorology to the greatest advantage.

The Division of Radiophysics is engaged on a series of experiments in cloud physics and artificial rain-making, which have now reached the stage of full-scale regional trials to assess whether rainfall can be increased significantly over a given target area.

Australia being the driest of the continents, the Organization is also attacking the problem of water supplies from another angle. In the Division of Industrial Chemistry, research is in progress on techniques to retard evaporation of water from dams and other storages. Again in full-scale field trials these investigations have shown that even on large areas of water, losses from evaporation can be very much reduced.

Investigations undertaken by the Division of Meteorological Physics at Aspendale, Victoria, are dealt with in Sections 2-7 of this Chapter. The work of the Division of Radiophysics on rain-making is described in Section 8 of this Chapter. The research of the Division of Industrial Chemistry on anti-evaporation of water is described in Chapter XVII., Section 5 (*a*).

Division of Meteorological Physics.—The research programmes of the Division have continued unchanged, and the year has seen no changes in senior staff.

Dr. Priestley, Chief of the Division, returned in November, 1957, after leave of absence working in the Department of Meteorology of the University of Chicago.

Members of the Division are giving a course of lectures on micrometeorology in the Department of Agriculture, University of Melbourne.

The Division is taking an active part in observations necessary for the International Geophysical Year.

2. Dynamic Meteorology.

(Division of Meteorological Physics.)

There is a pressing need in meteorology to know the effects of heating on flow patterns, and many so far unexplained phenomena on the largest scale, such as monsoons and the details of seasonal behaviour, depend on these effects. The distribution over the southern hemisphere of the summer heating of the air below 10,000 ft. is being mapped, as the first step in assessing the influence of the Australian continent on the whole flow.

Strongly stratified air is common over Australia and gives rise to a variety of associated problems. It is strongly affected by orography, and the structure of lee waves, which can become a flying hazard, is under experimental investigation in collaboration with the University of Melbourne and the Royal Australian Air Force. The theory of Antarctic katabatic (downslope) winds, developed in 1956, has been recently tested, and the sudden onset and cessation of wind shown to be similar to the hydraulic jump in an open channel. Another analogy, between the large-scale horizontal flow of the mid troposphere and the vertical perturbations of a stratified fluid, has been found theoretically and opens up prospects of new lines of attack on the large-scale problem.

A study of jet streams in collaboration with the University of Melbourne revealed areas of negative absolute vorticity associated with strong horizontal and vertical wind shear. A year's statistics were built up on the distribution of the jet axis in eastern Australia in space and time.

For quantitative rainfall prediction, statistical relationships were derived between frontal passages, upper winds, stability, humidity, and daily rainfall for Melbourne in spring. The two most promising indices were stability and humidity, but much residual variance remained.

Studies of the mechanism of cool changes have continued. It is necessary to supplement the simple model of the Southern Ocean front, especially for changes occurring in two stages. The differential heating between land and sea carries evidence for the formation of a " coastal front " south of the continent, which influences the weather sequence associated with the change, while the cooling of warm air over water should help to explain the frequently unexpected early arrival of the front. The time of arrival is urgent in connexion with bushfire control. Special wind measurements are disclosing unsuspected features in the shape of the wedge of undercutting cold air.

Recognition of the effect of surface friction has led to advance in the theory of fronts, and it may be possible to classify into deep and shallow fronts, and into upsliding or downsliding conditions (the critical factor with regard to rainfall), according to the exact pattern of surface isobars.

A factual study of the incidence of Australian tornadoes and the wind speeds associated with them is nearing completion.

3. Micrometeorology.

(Division of Meteorological Physics.)

Radiation from the Sun becomes available for atmospheric processes, in the main, only after absorption at the Earth's surface. This energy is passed into the atmosphere by radiative and turbulent transfer of heat, and by evaporation. The exchange of mechanical energy between the atmosphere and the Earth is achieved almost entirely by friction at the surface. Weather phenomena on all scales depend ultimately on these exchanges, which in turn are governed by physical processes occurring in the layer of air immediately above the surface.

Through observations of the fine structure of temperature, water vapour, and air motion the principal aim has been to elucidate the laws governing the exchange of heat, water vapour, and momentum. Specially responsive equipment has had to be developed. The most recent work has defined the response requirements with some precision, with wind speed, height of observation, and stability the main determining factors, and serves to calibrate the results from earlier measurements.

The study of temperature profiles under conditions of strong convection has been extended to include wind profiles. Simultaneous records of temperature fluctuations at different heights up to 100 ft. outline the pattern of motion and deep penetration of the convective elements. The structure of the turbulence is also being examined in respect of velocity and temperature correlations over distances of 50-100 ft. These are fundamental background studies with many applications: the transfer problems above, seed and spore dispersal, atmospheric pollution, and wind stresses on aircraft and fixed structures.

A mechanical harmonic analyser, designed and built in the Division, is now in operation and is being used to examine the spectra of atmospheric turbulence. It has been used in an analysis of gusts likely to be experienced by the radio-telescope structure presently being designed for the Division of Radiophysics (see Chapter XXVIII., Section 3).

The instrument developed to provide an accurate, automatic measure of natural evaporation has undergone further extensive trials with satisfactory results. This has encouraged development of a Mark II. model which is now well advanced in the design stage. It will embody compactness and comparative simplicity and economy in operation, and should go far to meet a pressing need in a wide variety of activities involving a knowledge of the water balance. These, ranging from the purely meteorological to studies in agricultural research, include requirements met in irrigation and water conservation practices.

Studies have continued of the exchange of energy and frictional stress between atmosphere and ocean, the F.R.V. *Derwent Hunter* again having been loaned by the Division of Fisheries and Oceanography for this purpose for three weeks in May, 1958. A body of observations was secured in a wide range of wind speeds which will supplement the results of previous trials. These have shown, *inter alia,* that the stress exerted by light winds is rather less than had been thought previously.

4. AGRICULTURAL METEOROLOGY.

(Division of Meteorological Physics.)

The instrumentation developed for studying atmospheric turbulence has been used in a variety of agricultural problems. A small section has been formed to follow up these aspects, with major emphasis on evaporation from growing crops under varying conditions.

Four of the battery of twelve large soil containers (diameter 5 ft. 3 in., depth 4 ft.) are now in operation, and measurements are being made of evaporation loss from different bare soils under conditions of plentiful moisture supply. Concurrently instrumentation is being set up to provide the micrometeorological observations necessary to a proper interpretation of the performance of these lysimeters.

Full exploitation of the lysimeters (the first installation of its kind in Australia) will not be possible until each container is provided with its own weighing equipment. The necessary accuracy (one part in 14,000) makes heavy demands on design and accuracy of fabrication. A prototype instrument has been designed and built within the Division's workshop. This machine, a development of one built in England at the National Institute of Agricultural Engineering, is now ready for trial.

5. RADIATION.

(Division of Meteorological Physics.)

The programme of radiation studies has been intensified. Continuous recordings have been begun of:

(*a*) Total insolation received by a horizontal surface.
(*b*) The sky contribution to (*a*).
(*c*) The long-wave (infra-red) radiation from the atmosphere.
(*d*) The net radiation income of a grass surface.

A new weatherproof radiometer of high sensitivity is under development for radiation balance measurement and is to be employed in a study of the variation of radiative flux with height in the lowest 100 ft. at night—a matter of interest in problems of frost prevention, fog formation, &c.

6. OZONE INVESTIGATIONS.

(Division of Meteorological Physics.)

Measurements by the Dobson spectrophotometer of the ozone amount at 20-50 km. height have continued through the year. This investigation is under international auspices. Australian observations are taken at Brisbane by the Bureau of Meteorology, by the Antarctic Division (Department of External Affairs) at Macquarie Island where good results have been obtained in the face of difficult conditions, and at Aspendale by this Division, which is responsible for the co-ordination and interpretation of results. The locations were chosen with the requirements of the International Geophysical Year in mind. Local variations may be related to the weather situation, while, more generally, the results are of significance in the radiation balance and indirectly for health reasons, while their evidence on the general circulation at high levels assumes a new importance from the question of global distrubution of the radioactivity from nuclear explosions.

7. MISCELLANEOUS INVESTIGATIONS.

(Division of Meteorological Physics.)

As a further contribution to the International Geophysical Year, the amount of radioactivity in precipitation is being determined in Melbourne and environs. Chief interest lies in the activity from long-lived isotopes, and monthly samples are being collected from four stations.

A calibration service for anemometers is provided for outside bodies, and the Laboratory is now registered with the National Association of Testing Authorities for such work. Among physical apparatus designed for research in the Primary Divisions, work is on hand on a single pen recorder for recording water levels, rainfall, temperature, or humidity for up to twelve months unattended. The instrument is intended to be comparatively inexpensive and of low installation cost for operation in remote areas.

8. CLOUD AND RAIN PHYSICS.

(Division of Radiophysics.)

Experimental investigations of the physical processes responsible for the formation of cloud and rain were initiated in the Division in 1947, following the demonstration that certain types of cloud could be induced to rain by seeding them with dry ice. The initial objective—to provide a sound background against which this potentially important discovery might be properly assessed—has largely been realized, and one important aspect of current work is a series of large-scale practical rain-making trials designed to provide the essential data on which the economics of artificial rain-making techniques can be realistically assessed.

Rain occurs naturally by one of two quite separate physical processes: by ice-crystal formation in supercooled clouds, and by the coagulation or coalescence of water droplets in clouds which are warmer than freezing. The Division's earlier work established that certain minute dust-like particles in the atmosphere ("nuclei") play a vital part in initiating both types of rain, and that by supplying appropriate substitutes when naturally occurring nuclei are absent or ineffective rain may be induced artificially. Work during the past year has been devoted for the most part to further studies of the nature and occurrence of "freezing" nuclei, i.e. those responsible for initiating the rain-forming process in super-cooled clouds, and to large-scale field experiments using the most effective artificial freezing nuclei yet discovered, namely, crystals of silver iodide.

(*a*) *Cloud Formation and Properties.*—Measurements of the liquid water content of cumuli by two independent methods have shown that there is much less water present than would be expected on the basis of the simple adiabatic model of cloud growth. This can be explained only by the mixing of dry air with the rising current of moist cloud-forming air. It has been shown that the dry air which is usually found at the levels of the tops of cumuli can penetrate deeply into the cloud in the form of "penetrative downdraughts". These downdraughts arise because the dry air, on mixing with the cloud, causes the droplets to evaporate, so that it is cooled, becomes denser, and sinks. In this way, a number of observed features of cumulus clouds can be explained.

The extremely rapid variations in properties which are found during an aircraft traverse of a cloud could be caused by downdraughts of varying age and vigour reaching down from the region of the cloud top to the level of the traverse, and below. Fast responding instruments have been designed with the aim of measuring the fine structure of cumuli in order to test out the theory of penetrative downdraughts. According to this hypothesis, small regions of the cloud which are deficient in liquid water should also be colder than their surroundings, and should be moving downwards relative to the cloud as a whole.

The theory of the glaciation of cumuliform clouds previously developed to explain the generation of electric charges in thunderstorms has been extended to give an indication of the correct seeding rates to use in attempts to stimulate precipitation. The silver iodide generators of the type currently in use theoretically give about the right number of nuclei for average conditions, but there is scope for improvement in the case of clouds which do not extend far above the freezing level.

Studies of the relation between the microstructure of warm clouds and their ability to produce rain, based on observations made in Australia and in Hawaii during Project "Shower", have been completed. The marked differences previously found between maritime clouds, which readily yield rain, and continental clouds, which are much less efficient rain producers, may not be attributable to the presence of relatively large sea-salt particles in the atmosphere over the oceans, as was previously supposed. This question can be solved finally only by measuring the smaller and more numerous cloud-forming particles, or nuclei, and preliminary work has begun on this difficult instrumental problem.

(*b*) *Natural Rain.*—Further studies of the occurrence of the minute naturally occurring nuclei which are responsible for initiating the rain forming processes in supercooled cloud (the so-called "freezing" nuclei) have confirmed that their concentration tends to vary simultaneously at widely separated localities, and around the same calendar dates each year.

(i) *Measurement of Freezing Nucleus Concentration.*—The improved freezing nucleus counters described in last year's report were installed at four Australian stations and operated by Weather Bureau personnel from November, 1957, to February, 1958. In addition, the Division supplied freezing nucleus counting equipment to other interested groups at the following sites: Farnborough, England; Puerto Rico; West Coast of the United States of America; East Coast of the United States of America; Hawaiian Islands; and New Zealand.

The results followed closely the pattern of preceding years, and showed an overall tendency to maxima on certain dates close to those predicted by Bowen's theory of a meteoritic influence on weather. The same pattern was confirmed by independent observers in the United States of America, Germany, and South Africa, using different equipment.

It has become clear from these (and earlier) measurements that large fluctuations in freezing nucleus content may be patchy and short-lived. An automatic nucleus sampler is at present being developed to provide a virtually continuous record of variations in the freezing nucleus concentration.

(ii) *Meteoritic Dust and Rainfall.*—The discovery that rainfall tends to be heavier on certain dates of the year, and that these dates occur approximately 30 days after the Earth's passage through the orbits of the known meteor streams, led to the formulation of Bowen's theory of a meteoritic influence on weather.

Rainfall data covering long periods of years from many parts of the world confirm the existence of preferred rainfall dates, and measurements of the freezing nucleus content of the atmosphere made at many widely separated places during the month of January, in particular, over several consecutive years have shown that the freezing nucleus count tends to be high around the dates predicted by the theory. Considerable instrumental difficulties are involved in establishing the presence of dust of extra-terrestrial origin at very high levels in the atmosphere. However, one of the Division's freezing nucleus counters has been adapted for use in a pressurized aircraft and a trial series of measurements has been made at altitudes below and above the tropopause. Preliminary indications are that the nucleus count above the tropopause is not lower than that below it.

The regular observations of meteor activity by radio methods at Adelaide University have been continued.

(iii) *Cirrus Cloud and Rainfall.*—The incidence of cirrus cloud at representative stations throughout Australia has previously been found to show fluctuations of large amplitude whose maxima coincided closely with those of the rainfall for a much longer period and wider area. During the past year data on cirrus cover have been collected from other countries, and it is already clear that a close correspondence between cirrus cover and rainfall peaks exists also for certain other parts of the world. Its greater abundance some 30 days after the Earth's passage through meteor orbits provides support for the theory for a common origin in meteoritic dust.

(*c*) *Artificial Stimulation of Rain.*—The experimental programme in the artificial formation of rain covers three phases: attempts to stimulate rain over large areas; seeding of individual clouds; and more detailed investigations into the processes involved. In the period under review a large effort has been devoted to cloud seeding of an *ad hoc* nature in an attempt to alleviate the drought conditions which prevailed in the eastern States. Continuity is essential in the large-scale experiments, and the effort devoted to drought relief has detracted from that available for the other projects.

(i) *Large-scale Cloud Seeding.—The Snowy Mountains experiment.*—The Snowy Mountains experiment is being continued and has now been in operation for three winter seasons. The seeding season is divided into periods of about two weeks' duration; during any one period clouds over a target area of approximately 1,000 square miles are either seeded with silver iodide smoke released from an aircraft, or not seeded at all on a random basis. The rainfall in this target area is carefully measured, and compared with that in an adjacent unseeded area, the relation between the natural rainfall in the target and control areas being determined during the unseeded periods.

In the seeded periods there has, on the whole, been more rain in the target area than would have been expected judging by the rainfall in the control area. The difference between the seeded and unseeded periods is at about 97 per cent. level of significance, and the probable magnitude of the increase in rainfall is 15 per cent. The significance of the results has increased as the experiment progressed, but the estimated magnitude of the rainfall increase has not changed. In the third season rainfall was low and opportunities for cloud seeding were fewer than in previous seasons.

Operations will continue for at least another year to enable the results to be assessed with greater confidence.

The South Australian experiment.—An experiment similar to that over the Snowy Mountains is in progress in South Australia. Two areas, each of approximately 1,000 square miles, have been selected in the hills north of Adelaide, clouds over one or the other being seeded for a period of about two weeks. This procedure is expected to increase the ease of detection of the effects produced by the seeding compared with that used in the Snowy Mountains experiment, where only one area may be seeded because rainfall is not desired in the control area. The experiment, which is restricted to the winter months, commenced in April, 1957, and will be continued, probably for some years, to determine the results over a long period.

The New England experiment.—An experiment exactly similar to that in South Australia was commenced in February, 1958, in New England. Two experimental areas are centred respectively at Tamworth and Inverell, and one or the other is seeded. This experiment will continue all the year round with the exception of November and December, when it will be suspended in the interests of the wheat harvest. It is expected to continue for several years.

The Warragamba catchment.—A preliminary survey was conducted in November, 1957-January, 1958, in co-operation with the Sydney Water Board to assess whether this area was a suitable one in which to carry out a long-term large-area experiment similar to those described above, and to attempt to cause precipitation which would help fill the Warragamba Dam and thus relieve Sydney's water shortage.

Clouds were seeded and precipitation followed. The survey was terminated when heavy rains caused the Dam to overflow, but how much of the precipitation was due to the seeding is not known as this was not a controlled experiment.

The tentative conclusion was reached that the Warragamba Catchment Area would be suitable for a controlled experiment.

The Corella catchment.—A preliminary survey of the cloud seeding possibilities in the catchment area for the Corella Dam, which is situated between Mount Isa and Cloncurry, Queensland, was conducted in co-operation with Rio Tinto Construction and Development Pty. Ltd., during January-April, 1958. Cloud seeding was carried out but the area was not considered particularly suitable for a long-term experiment. A secondary objective was to try to increase precipitation so as to help fill the Corella Dam; some rain fell and the water level rose, but, because of the lack of control data, it is not known how much of the rain was due to seeding.

The drought relief operations.—The incidence of drought conditions in the first half of the year under review led to requests from the Governments of New South Wales, Queensland, and Victoria that C.S.I.R.O. should carry out cloud seeding operations in an attempt to relieve the situation; considerable effort was, in fact, expended in drought relief operations during the year. These were conducted in co-operation with the State Departments of Agriculture and the Weather Bureau; the former specified where rain was most urgently needed, and the latter indicated where clouds suitable for seeding were most likely to occur. Aircraft were stationed at locations chosen as a compromise between these two factors, and when clouds appeared they were seeded. There is some circumstantial evidence that rainfall was increased considerably in Queensland and slightly in New South Wales, but in Victoria no clouds suitable for seeding appeared during the periods when aircraft were available in that State.

In these operations DC-3 aircraft were used, the number in operation at one time varying from one to four. Crews were provided by the Royal Australian Air Force, and each operation was in charge of an officer from the Radiophysics Division.

(ii) *Stimulation of Individual Clouds.—Silver iodide:* An important factor in cloud seeding (on which at present little information is available) is the relation between the number of freezing nuclei supplied to a suitable supercooled cloud and the amount of rain stimulated. An attempt to determine this relationship is to be made by seeding selected clouds with silver iodide burners, which produce different quantities of nuclei, and determining the quantity of rain which falls. Suitable statistical controls will be applied.

The electrical techniques.—An attempt was made to develop apparatus for increasing the coalescence rate of cloud droplets, by charging them to opposite polarities. A high-voltage alternating potential was to be applied to wires extended below a Lincoln aircraft by a trailing " bomb ". This project has been abandoned.

(iii) *Properties of Freezing Nuclei.—The mechanism of nucleation:* Because the way in which natural or artificial nuclei produce ice crystals in the atmosphere is not well understood, some basic work has been started on this problem. Large crystals of silver iodide and lead iodide were grown and the growth of ice crystals upon their surfaced studied microscopically. Among other things it is found that the ice crystals grow with their axes parallel to those of the nucleating crystal upon which they form.

A theoretical treatment of the nucleation process has led to an understanding of the effect of the size of nucleating particles upon their ability to produce ice crystals under given conditions, and thus to a specification of the most desirable size of silver iodide particles for use in cloud seeding. It has also been possible to distinguish between sublimation nuclei which produce ice directly from water vapour, and freezing nuclei which first condense a droplet of water which subsequently freezes.

The aircraft generator: A new type of silver iodide smoke generator for use on aircraft has been developed. It is self-contained, and is lighter and more compact than the type at present in use. It burns the same acetone-sodium iodide-silver iodide solution as is used in the existing type of burner. Its performance is satisfactory on the ground and its freezing nucleus output in the air will be tested shortly.

Ground generators: Alternative methods for the production of freezing nuclei have been developed, some of which give promising results when tested on the ground. Airborne tests will be carried out shortly.

XXVIII. EXTRATERRESTRIAL PHYSICS.

1. General.

Radio astronomy is one of the most recent sciences, and stems from the discovery that heavenly bodies emit radio waves as well as light waves. Working side by side by scientists using optical methods, radio astronomers have been able to uncover new knowledge, not only of the Sun and planets from our solar system, but also of the Galaxy, of which we are part, and of the innumerable galaxies beyond. The radio telescope has set new boundaries to space, far beyond those at the limit of optical vision. In addition, study of the 21 cm. spectral line of atomic hydrogen has yielded a new conception of the distribution and the nature of matter pervading interstellar space and the transformations which this matter undergoes in the creation of heavenly bodies.

Radio astronomy has formed a major part of the research programme of the Division of Radiophysics (see Section 3 of this Chapter). Studies of the ionsphere are carried out by the Radio Research Laboratories (see Chapter XXVI., Section 7). Work on solar radiation is carried out by the Division of Physics (see Section 2 of this Chapter).

2. SOLAR PHYSICS.

(Division of Physics.)

The cinematographic observations of the chromosphere have been continued as part of Australia's contribution to the International Geophysical Year and the films obtained have provided much valuable data. The study of the relationship between flares and surges and of the height distribution of limb flares has been completed, and the occurrence of a very short-lived flare in a prominence has been described.

With the co-operation of the Division of Radiophysics (see Section 3 (*b*) (ii)), the association between a class of radio bursts conventionally known as type II. and optical features in the chromosphere has been investigated. It has also been found that the probability of an association between a type III. burst and a flare is enhanced when the flare displays an initial bright expansion. To throw some light on the physical conditions in flares measurements have been continued of a series of low-dispersion spectra obtained in 1956.

Using the 5-in. photoheliograph, studies of sunspots and the solar granulation have been continued at the Solar Station at Fleurs, some 30 miles west of Sydney. Among the problems investigated have been the lifetimes of the filaments in the spot penumbrae, the development of minute bright regions on the borders of umbrae, and the changing appearance of a spot as it moves across the solar disk due to its lower absorption coefficient compared with the surrounding material.

The optical components of the ⅛ Å tunable filter have been completed and a preliminary assembly has brought to light some problems which require further investigation.

The chromospheric patrol telescope at Sydney has been equipped with an alternative high-magnification camera, which will be used to investigate possible correlations between chromospheric and photospheric features. Some observations have been made to determine the feasibility of detecting magnetic fields on the Sun with the aid of an $H\alpha$ birefringent filter.

3. RADIO ASTRONOMY.

(Division of Radiophysics.)

The various special radio telescopes developed by the Division have been in regular use throughout the year for the study of radio waves which are constantly reaching the Earth from the Sun, from the Galaxy, and from the depths of space that lie beyond. The Division's programme covers the major fields in radio astronomy and is more comprehensive than that being carried out at any other centre.

An important step in the realization of a " giant " radio telescope for Australia was the decision to proceed with one having an aerial 210 ft. in diameter, mounted in altitude-azimuth fashion. This design was evolved by the British firm of engineering consultants, Messrs. Freeman, Fox, and Partners, in close collaboration with the Division, and embodies several novel features which will result in an instrument of outstanding performance. After careful consideration of possible alternatives a site has been selected near Parkes, New South Wales, some 200 miles west of Sydney. Preliminary construction work will commence during 1958, but the radio telescope will not be ready for operation until 1961.

(*a*) *Radio Waves from Beyond the Solar System.*—(i) *The Spiral Structure of our Galaxy.*—Interstellar hydrogen is concentrated in the spiral arms and in the galactic disk, and because of the characteristic radiation which it emits at a wavelength of 21 cm., can be used as a tracer to explore these parts of the Milky Way Galaxy. The main difficulty in determining the space distribution of the hydrogen in the Galaxy is that the distance of the gas cannot be measured directly, but must be inferred from an indirect argument, which is based on measurements of the motions of the gas.

A first picture of the spiral structure of the whole Galaxy has been produced, in collaboration with workers at the Leiden Observatory, who have made similar observations in the Northern Hemisphere. This picture appears to give a first approximation, but the problem is complex and further observations with higher resolving power are necessary, together with advances in interpretation. The latter may come in part from comparisons between radio and optical observations in the nearer parts of the Galaxy.

It has recently been found that most of the gas in the nuclear regions is moving outwards from the galactic centre, possibly in the form of embryo spiral arms. This phenomenon adds to the difficulty of delineating the spiral structure, but a study of it should lead eventually to a better understanding of the way in which spiral arms are produced in the Galaxy.

The layer of hydrogen is exceedingly flat in the parts of the Galaxy closer to the centre than the Sun. The mean plane indicated by the hydrogen in this region may have an important dynamical significance in the Galaxy. The International Astronomical Union is at present considering a revision of the reference plane for galactic co-ordinates, to bring it more into line with modern knowledge of the shape of the Galaxy. The Division has made a new determination of the position of the central plane which is based primarily on a study of the Sydney and Leiden hydrogen-line measurements, but conforms well to other available observations.

A receiver of a new type in which the frequency band is split up into 48 separate channels, tuned to a series of frequencies spread across the range in which the hydrogen line is to be found, has now been brought into operation. Early observations with the new receiver have shown its very great information-gathering power.

(ii) *Results from the* 3.5-*Metre " Mills Cross " Aerial.*—The Division's principal instrument for the study of galactic and extragalactic continuum radiation, the 1,500-ft. " Mills Cross " aerial, has virtually completed its original observing programme and is now being altered to measure approximately the angular size of radio sources down to about 15″ arc. This will allow the recognition of very distant sources, which are of significance in an investigation of cosmological problems, and be of great help in identifying many of the radio sources with visible objects. The alteration involves the addition of an extra aerial at a distance of about six miles from the original cross, to be used as an interferometer.

The observations have provided a vast amount of data to be analysed which entails the preparation of catalogues of radio sources. A catalogue containing 1,165 sources in an area rather less than half that accessible to the instrument has been completed. A statistical analysis of the catalogue confirms the earlier work on a more limited region described in the last report. No evidence is found for any dependence on the properties of the sources on distance, although it is found that simple models of their spatial distribution are inadequate. Angular size data, determined with the new instrument, are required before any significant advance is likely in this field.

A programme of identification of radio sources with visible objects is also under way. All the more obvious identifications have now been made (about three dozen), principally with bright hydrogen emission nebulae, bright external galaxies, and clusters of galaxies; the more arduous systematic investigations of galaxies which may be abnormally strong radio sources has now begun. There is promise of good results for southern objects through co-operation with Mount Stromlo Observatory, where the regions containing bright radio sources of accurately known positions are being photographed with the use of their new 74-inch telescope. So far about twenty galaxies have been noted which are suspected to emit radio waves abnormally. On a statistical basis, it appears probable that a few per cent. of all galaxies may have very much higher than normal radio emission.

The structure and properties of the radio Milky Way have also been investigated with this instrument. The majority of these observational data have now been analysed and maps have been prepared showing the distribution of radio emission in great detail near the plane of the Milky Way and in smoothed-out form over the remainder of the sky. Because of the high resolution of the instrument it has been possible to describe the structure of the Milky Way more decisively than has been possible hitherto. Three basic features have been recognized: a very widespread component extending to great distances from the galactic plane (called the corona), a much brighter component closely concentrated to the galactic plane (the disk), and a population of quite intense radio sources of small angular size (less than 1°) distributed along the well-defined ridge line of the disk component. None of these are directly related to any stellar component of the Galaxy, although the distribution of radio sources has similarities to that of the extreme Population I. stars, that is, the youngest and hottest stars. Work is continuing on the astrophysical significance of these results: there is probably a connexion with cosmic rays, galactic magnetic fields, and the physical processes in supernovae explosions. At present the latter appear to be the most likely progenitors of galactic radio sources.

A number of special objects and regions have also been studied, with the aim of elucidating some physical problems associated with them. These include the concentrations of ionized hydrogen in the neighbourhood of the Great Nebula in Orion, several clusters of external galaxies including the "Local Supergalaxy", and some of the stronger southern radio sources.

(iii) *Observations with the 15-Metre Wavelength "Cross" Aerial.*—The main observational programme during the year has been directed towards the completion of a survey of a belt of the sky, 10° wide, around the galactic equator. This programme is now practically complete, but some repeat observations are required and these will be made when the appropriate regions can be observed at favourable times of day. In addition, detailed surveys of other, smaller regions have been undertaken, notably in some discrete sources in the Magellanic Clouds, of the large HII regions surrounding ζ Ophinchi and in Vela-Puppis, and of the Orion region.

As a corollary to the disturbing effect of the ionosphere on the cosmic noise observations, it is possible to use these observations to study the ionosphere. The narrow beam of the 15-m. "Cross" aerial enables rather accurate measurements to be made of the apparent positions at transit of the stronger discrete sources, and a regular programme of observations is being undertaken from which the ionosperic refraction may be deduced. This information is needed in the reduction of the main series of observations, and it will also be related to the characteristics of the ionosphere as observed in routine ionospheric soundings.

The large angular extent of the source Centaurus-A (associated with NGC 5128) permitted the study of the brightness distribution in some detail. It has been possible to show that the extended component of this source has a different spectrum from that of the central, "point" source. Moreover, the extended component, which is very elongated, shows definite evidence of spiral structure, and it is suggested that this component might be a comparatively "young" feature of the galaxy NGC 5128. A comparison of Fornax-A (NGC 1316) and Centaurus-A showed that there are marked similarities between the two sources.

Detailed observations of the Large Magellanic Cloud now available have confirmed that the HII regions surrounding 30 Doradus is observed in absorption at 15 m., and as a result it can be estimated that distant extragalactic sources of emission can contribute no more than one-third (possibly less than one-fifth) of the radiation observed near the galactic poles; the rest must come from the galactic corona. The greatest uncertainty in this estimate is caused by the incompleteness of optical data. Meanwhile, even the present estimate is valuable both for cosmological theory and for theories of the galactic radio emission.

On the question of ionospheric refraction, one item of interest arising out of the preliminary investigation is the importance of horizontal gradients of electron density in producing a prismatic refraction effect. This often exceeds, and may oppose, the expected refraction due to ionospheric curvature (lens effect).

(*b*) *Radio Waves from the Sun.*—(i) *The Crossed-grating Interferometer.*—This instrument, the only one of its kind in operation, is producing each day a detailed radio picture of the Sun.

The first six months' records have been analysed and, as a result, the nature of the source of the so-called "slowly varying component" of the Sun's radio emission is becoming clearer. It seems that the active regions of the Sun, from which this radiation is emitted, consist of relatively dense columns of ionized hydrogen gas which extend from the chromosphere out to the upper parts of the corona. The presence of these dense regions is invariably indicated by the appearance of "plages" in optical chromospheric pictures of the Sun, and by local magnetic fields which probably hold the regions together. The radiation from them appears to be thermal, and it seems that these regions, because of their high temperature and density, provide the slowly varying component of both the X-ray and ultraviolet emission on the Sun which produce variations in the Earth's ionosphere and affect long-distance radio communication on the Earth.

A start has been made in interchanging the results of optical and radio observations of the Sun with overseas observers, and it is hoped that combining the results will hasten the solving of some of the mysteries of solar behaviour.

(ii) *The Solar Radio Spectrograph and Swept-frequency Interferometer.*—Observations of solar radio disturbances have continued throughout the year with the Dapto radio spectrograph which records the Sun's spectrum in the range of wavelengths between about 1.5 and 7.5 m. The recorded information is passed directly into the International Geophysical Year (I.G.Y.) data system and is used as the basis of various research investigations.

A new type of double radio burst has been discovered and has been interpreted in terms of an initial impulse emitted from the solar corona followed by its echo reflected from an inner level of the solar atmosphere. This phenomenon provides a potential new method of measuring the physical characteristics of the corona.

Using the spectrographic data which have been accumulated between 1952 and 1958, an extensive investigation has been made of the major, but rare, radio outbursts known as "spectral type II.". It has been found that such outbursts accompany only a few per cent. of all solar flares, but that these flares have a high probability of causing terrestrial magnetic storms one to four days later. This adds weight to a previous suggestion that the source of a type II. burst is the actual corpuscular stream originating in the flare and causing the subsequent magnetic storm on the Earth.

In co-operation with the Division of Physics (see Section 2) a careful study has been made of the relation between optical and radio events on the Sun. Characteristic optical phenomena accompanying the radio bursts of spectral types II. and III. have been identified—the former with high-velocity ascending prominences, the latter with a sudden expansion at the beginning of flares.

The swept-frequency interferometer, designed for the rapid measurement of positions on the Sun's disk over a wide range of wavelengths (4.3-7.5 m.), has been completed and is now in regular operation. A positional accuracy of 1 min. of arc is obtained using a two-aerial system separated by 1 km., and it was found necessary to add a second system of shorter separation (0.25 km.) in order to resolve certain ambiguities inherent in two-aerial interferometers. For rapid analysis of results, the system has now been provided with automatic following and calibration facilities, and these are controlled by a specially designed computer driven from a crystal clock. The records emerge in a form which allow the positional (and polarization) data to be passed to the I.G.Y information centre shortly after each outstanding event is recorded, to solve current problems associated with the origin of solar radio waves.

(iii) *The International Geophysical Year.*—The Division has continued to supply data on solar radio emission from the two special solar instruments referred to above, and from routine observations at several fixed radio frequencies, and to edit world-wide data on solar activity for publication in the *Quarterly Bulletin of Solar Activity.*

The Division has been appointed the Principal World Data Centre for Solar Radio Emission—the only field of I.G.Y. activities in which a world data centre has been allocated to Australia—and will thus have the responsibility for editing data received from the numerous I.G.Y. centres throughout the world for final publication in the *Annals of the International Geophysical Year.*

(*c*) *Low-noise Receiving Techniques.*—A recent development of considerable importance in the field of high-sensitivity low-noise radio receiving techniques has been the successful operation in the United States of America of solid-state devices, which are known as " masers ". The maser—whose name is coined from the phrase " microwave amplification by stimulated emission of radiation "—gains its amplification by the direct conversion of internal molecular energy into electromagnetic energy, and operates at the temperature of liquid helium. When used as a preamplifier for a conventional receiver the combination is capable of an ultimate sensitivity much greater than has previously been attainable, and hence is of particular interest in radio astronomy.

A small group has been organized within the Division to undertake the development of a maser suitable for hydrogen line observations with one of the Division's radio telescopes. Since the maser is an offshoot of work in the field of low-temperature paramagnetic resonance and a large fund of experience in this field already exists in the Division of Physics, the project is being run on a co-operative basis with that Division. In addition, an officer of the Division of Radiophysics has been stationed at Leiden Observatory, Holland, for work on a maser which is being developed there for radio astronomy purposes.

The prominence given to the development of maser devices has revived interest in a previously undeveloped principle of amplification which makes use of non-linear reactances in tuned circuits. This principle, known as " parametric " or " variable parameter " amplification, appears now to offer the possibility of very low noise amplification without some of the engineering complexities associated with the maser. Some work has been commenced within the Division on a parametric amplifier in which the non-linear device is a variable-capacitance semi-conductor diode.

(*d*) *Theoretical Studies in Cosmical Electromagnetics.*—Following a study of the variations of cosmic-ray flux over the earth, a model interplanetary magnetic field has been developed. It comprises magnetic lines of force extending more or less radially from the Sun, the ends being joined as loops beyond the Earth's orbit. The origin of this field, at the time of ejection of highly conducting solar gas, has been studied. The final product contains irregularities (in intensity and direction of the field) sufficient to scatter low-energy particles. An essential feature is anisotropy of diffusion of cosmic rays through the field.

Studies of solar flares have been continued in an attempt to understand the underlying mechanism. Processes of conversion of hydromagnetic energy to other forms have been studied quantitatively.

An earlier study of the Crab Nebula has been continued with the object of finding the origin of its magnetic field. It seems that magnetic energy was created long after the original supernova explosion and perhaps is still being created. The source must be nuclear energy, presumably stored in radioactive material which was created in or near the central star. A mechanism, previously considered, for converting nuclear to magnetic energy is the " self-excited dynamo " depending on induction electric fields. An alternative is being studied which may account for the presence of other cosmical magnetic fields.

XXIX. MATHEMATICAL STATISTICS AND MATHEMATICS.

1. General.

The Organization maintains a separate Division of Mathematical Statistics to provide workers in the various Divisions and Sections with specialized help in planning their researches and analysing their experimental results (see Section 2 of this Chapter).

Work on mathematical instruments and mechanical and electrical methods of computation is undertaken in the Section of Mathematical Instruments (see Section 3 of this Chapter).

Division of Mathematical Statistics.—Divisional activities have been extended and staff are now established at thirteen centres throughout the Organization. A new research unit has been established in accommodation provided by the University of Melbourne, and further appointments of staff have been made to the McMaster Laboratory and the Division of Food Preservation and Transport, and at Perth.

There have been material developments in electronic computing. Requests for assistance have been steadily received by the officer attached to " CSIRAC " at the University of Melbourne. In Adelaide, the Weapons Research Establishment of the Department of Supply has continued to provide facilities for conducting a large-scale meteorological analysis, by allowing the Division regular time on their rostered programme for the use of " WREDAC " and its ancillary equipment.

Mathematical Instruments Section.—The research projects of the Section have continued along the lines of previous years, and close collaboration has been maintained with the Electrical Engineering Department of the University of Sydney.

The Section's activities have been mainly directed towards the completion of A.D.A., a special-purpose digital computor known as a digital differential analyser.

2. Mathematical Statistics.

(Division of Mathematical Statistics.)

The following is a summary of research projects completed or in progress within the research programme of the Division of Mathematical Statistics.

Calculation of the moments required for the distribution of the canonical correlations has been completed.

Integrals which arise in multivariate analysis have been expressed as Bessel functions of matrix argument, and partial differential equations derived for them. Finding the zonal functions of the irreducible components of the representation of the real linear group on the polynomials in the elements of a positive definite symmetric matrix is an alternative method for evaluating these integrals.

Group theory and algebras have been applied to the solution of normal and missing value equations.

Further work has been done on the analysis of variance and covariance of incomplete experimental data.

Research has been completed on the logarithmic transformation for the estimation of non-linear parameters, and the problems involved in the use of growth curves and their particular functional forms have been reviewed. Other activities include statistical problems in astronomy, ranking tests, and estimators in multiple regression analysis.

A long-range investigation of Australian steels is being conducted as a joint research project between Broken Hill Proprietary Limited and the Organization.

Theoretical analysis has been completed of the stress distribution occurring in a glued timber joint. The solution involves a transformed bi-harmonic equation, which is being evaluated numerically on "CSIRAC" by using finite difference equations.

Research has continued on interpolation of monthly rainfall in terms of the position and altitude of observing stations, and an investigation giving interpolates of high accuracy has now almost been completed.

Following the successful analysis of the intercorrelations of monthly rainfall in South Australia, the scope of the work has been extended, to include a large portion of the south-eastern section of the continent, stretching from Eyre Peninsula to western Victoria, and applied to the rains of a much smaller time interval, namely, six days.

3. MATHEMATICAL INSTRUMENTS.

(Mathematical Instruments Section.)

The construction of the transistorized digital differential analyser, A.D.A., is now complete. A.D.A. is believed to be the first machine of this type built outside the United States of America, and is among the first digital machines completed which makes exclusive use of transistors (1,400) instead of valves. The machine was first demonstrated at the Conference of the Institution of Engineers (Australia) held in Newcastle, February-March, 1958, and was officially opened in Sydney on 11th March, 1958, by Dr. A. Basser. A description of the machine was given before a conference on Computing Machines and Data Processing at the Weapons Research Establishment, Salisbury, South Australia, 1957.

The techniques used are now being applied to the development of a small general-purpose computer. This project is being supported by the Snowy Mountains Hydro-electric Authority, for whose use the first machine is intended.

XXX. RESEARCH SERVICES.

1. LIBRARIES.

Both staff and holdings in the library network have increased during the year, and there has also been an increase in the number of enquiries answered. The first loose-leaf volume of Scientific Serials in Australian Libraries has been produced, and the Australian Science Index has been separated from the C.S.I.R.O. Abstracts.

With the realization that neither this Organization nor any other scientific establishment will have the staff or resources to cope with the rapidly increasing volume of recorded knowledge, the emphasis of the library work is being changed from preoccupation with union lists, bibliographies, and library gadgets, to a development of greater co-operation in library service.

Scientific staff must be given a maximum degree of access to the wide variety of material in print, and it is essential that this be achieved by creating access to, rather than attempting ownership of, a multiplicity of publications.

A large building at Maribyrnong has been made available as a depository store to house little used or duplicate material. Ultimately it is hoped that, after a careful survey of the resources of each library, it will be possible to develop a scheme of rationalization whereby any work in the scientific or technical field likely to be needed by research men in Australia is available to them, without unnecessary duplication of holdings. One further step in this direction has been the cataloguing and recataloguing at several of the Divisions and Sections with a consequent filling of gaps in holdings.

2. TRANSLATION.

The Translation Section has carried out translations, both written and oral, as required by Divisions and Sections of the Organization. It has been possible, in many instances, to take advantage of the increasing publication of cover-to-cover English versions of important foreign, and particularly Russian, periodicals. Nevertheless, the number of written translations of Russian papers was some 50 per cent. greater than for the preceding year. For languages other than Russian, the number was about the same. In Sydney, the demand has warranted the employment of a translator, part-time, solely for oral translation from Russian.

The Section has operated as Australian agent for the Index of Translations of the British Commonwealth Scientific Office, and has also supplied microfilm copies of all its own translations from Russian to the John Crerar Library, Chicago, the approved body in this respect in the United States of America.

The languages now being handled within the Section are German, Dutch, Swedish, Norwegian, Danish, French, Italian, Spanish, Portuguese, Russian, and Ukrainian, and in some fields, Rumanian, Polish, and Czech.

3. ENGINEERING SECTION.

The Engineering Section carries out engineering research and development in certain specific fields. It also designs and builds special equipment for other Divisions and Sections of the Organization. Activity during the past year has been largely related to the development of equipment and automatic control systems for the precise control of environment, both for general laboratory applications and also for plant and animal studies. Work on the utilization of solar energy has continued and agricultural engineering research has been expanded by the addition of a small group which had been previously working in this field at the Fodder Conservation Section.

Towards the end of 1957 the Section occupied its new premises at Highett.

(*a*) *Phytotron Project.*—Development has continued of the phytotron for the large-scale study of plant growth under controlled environment conditions. The project is being carried out in close collaboration with the Division of Plant Industry and substantial progress has been made. Cabinets of two different sizes are being constructed in which plants can be grown under controlled day and night temperatures, and with controlled length of day. Prototypes of these and also of a third unit, designed to cool the glass-house in which the cabinets are located, have been tested for extended periods. Further cabinets now are being constructed for installation in a glass-house at Canberra, where they can be tested from both biological and engineering aspects under actual operating conditions. Designs are being prepared for a prototype section of the phytotron building, to be erected in Canberra before the end of 1958, and equipped with cabinets which will operate through the summer and yield essential data for the final building design.

Special types of cabinet are also being developed for the project, including temperature controlled enclosures in which plants will be grown under high-intensity artificial lighting. The provision of humidity control in naturally and artificially lit cabinets is being studied, together with problems associated with the development of special low-temperature units. All refrigeration systems operate on the constant evaporator pressure principle and use restrictor tubes in preference to expansion valves. Test facilities have been established to calibrate restrictor and capillary tubes.

In the final installation, a centralized control and monitoring system is being provided which will regulate the cyclic day and night temperatures and lengths in each cabinet. The monitoring system will indicate and record for each cabinet the nature and extent of departures from the pre-set régimes. Data processing techniques are being used in an attempt to simplify the elaborate statistical analyses often required in biological work. The use of automatic data processing may well prove to be one of the important advantages of this type of phytotron design.

A programme has been drawn up covering the completion of development work, the erection of the building, and the bulk construction of various types of cabinet.

(*b*) *Heat Pump*.—With the use of data obtained from a pilot-scale heat pump during the winter of 1957, a full-size installation has been put into service, in one of the Section's new buildings at Highett. The equipment uses atmospheric air as the source of low-grade heat, and supplies this heat at a higher temperature level to offices and laboratories through small individual fan and coil units. Precise data on the coefficient of performance obtained are not yet available, but from preliminary observations the heat pump would appear able to provide the most economical means for space heating under Australian conditions, especially if summer cooling is also required.

(*c*) *Solar Energy*.—Following the original work of Tabor in Israel, surfaces are being developed capable of selective absorption of solar radiation. The object is to enable radiation to be absorbed efficiently at a higher temperature level than is otherwise possible, and thus pave the way for the development, among other things, of a solar refrigerator and a solar space heating and cooling system.

The effects are being studied of orientation on the performance of the solar water heater, and a method of preventing damage to the equipment through freezing has been developed. The results have been analysed of year-round operation of experimental water-heater installations in various parts of Australia, and data prepared on the economics of operation under differing climatic conditions.

(*d*) *Temperature Control Equipment*.—The limitations of commercially available sensing and control devices are normally the factors determining the accuracy with which temperature can be controlled in a room or similar enclosure. For applications where commercial instruments are unsuitable an electronic temperature controller has been developed, which uses a thermistor as the sensing element, and, after amplification of the signal, a novel type of electronic switch to control the heating or cooling function through a relay. Where heating and cooling are both controlled, two switches are used; the neutral zone between them can be adjusted, and if necessary the operating zones can overlap.

(*e*) *Thermal Transducer*.—A controller of the type described above, providing on-off control of heating or cooling functions, will be unstable in operation and will overshoot control limits owing to heat storage effects. To overcome this a thermal transducer has been developed for use with the controller. The transducer is an integrating feed-back device with an inherently long time constant, and it operates so that the supply of energy to the heater or cooler is disconnected sufficiently early to ensure that the temperature rise or fall just reaches the desired value and does not exceed it. The potential applications of both the thermal transducer and the electronic temperature controller extend into many other fields besides temperature control.

(*f*) *Agricultural Engineering Research*.—Investigations into the kinematics of the mowing machine have now been completed, and data have been obtained on the forces involved in the cutting process. This information is now being used to build a prototype machine embodying these improvements for testing under field conditions.

In the original investigations the magnitude and direction of the cutting forces were measured by a system of strain gauges and a multi-channel oscilloscope. While this method proved satisfactory, the work involved in evaluating the oscillograms by conventional processes was considerable, and a new technique has been developed which enables the data to be processed on to punched tape and then handled by the CSIRAC computer.

A grab type of silage loader has been developed, and a prototype subjected to extensive field trials.

Equipment is being obtained for the new project on wheat production to be financed from wheat research funds. This work will be confined initially to a study of the basic characteristics of the disk plough, and of the heat transfer and moisture movement processes in bulk wheat storages.

(*g*) *General Engineering*.—An experimental salting and hooping machine was constructed for the Dairy Research Section, as part of their equipment for the mechanization of Cheddar cheese manufacture. The machine is arranged for continuous operation in the cheese production line, applying salt to the milled curd in regulated quantities and weighing the cheese into hoops for subsequent pressing. The weighing process is a batch operation, the curd being held up in the machine while a filled hoop is automatically replaced by an empty one. The process is controlled by a novel system, which uses phototransistor relays in conjunction with the electronic switch previously described in Section (*d*) to control the flow of curd and the movement of the hoops.

A large lysimeter was constructed for the Irrigation Research Station at Griffith, to a design originating from the National Institute of Agricultural Engineering in England. Laboratory tests have shown that the unit is capable of detecting and recording extremely small changes in the weight of the soil held in its container, and a second similar unit is now under construction. A large pad mangle was built for the Wool Textile Research Laboratory, Geelong, for use in shrinkproofing investigations. The machine has rubber-coated rollers 12 inches diameter by 66 inches long, which can be rotated at varying speeds while loaded hydraulically at any value up to a maximum of 16,000 lb.

XXXI. PUBLICATIONS, EXTENSION, AND LIAISON ACTIVITIES.

1. General.

The Organization's research results are made available through various channels.

Formal scientific publication is supplemented in several ways: by the preparation of films (Section 6 of this Chapter); by the continuous and close contact with industry of officers of the Divisions and Sections; by the provision of facilities for guest workers in laboratories; by the publication of trade circulars, newsletters, and articles in trade journals; by press releases; by lectures and short courses of specialized training; and by the organization of specialist conferences.

The application of research in the primary industries is being assisted by the work of the Agricultural Research Liaison Section (Section 3 of this Chapter).

The application of research in the secondary industries is being assisted by the Industrial Research Liaison Section (Section 4 of this Chapter).

Section 5 of this Chapter deals with the work of the Organization's Scientific Liaison Offices in London and Washington.

2. PUBLICATIONS.

The Organization continued its co-operation with the Australian Academy of Science to ensure the maintenance of a high standard in papers appearing in the following scientific journals published by the Organization:—

- *Australian Journal of Agricultural Research.* Six issues a year.
- *Australian Journal of Applied Science.* Issued quarterly.
- *Australian Journal of Biological Sciences.* Issued quarterly.
- *Australian Journal of Botany.* Issued as material becomes available.
- *Australian Journal of Chemistry.* Issued quarterly.
- *Australian Journal of Marine and Freshwater Research.* Issued as material becomes available.
- *Australian Journal of Physics.* Issued quarterly.
- *Australian Journal of Zoology.* Issued as material becomes available.

General editorial policy is decided by a Board of Standards comprising Professor J. G. Wood (Chairman), Dr. N. S. Noble (Editor), Professor J. S. Anderson, Professor Sir Macfarlane Burnet, Professor Sir Leslie H. Martin, and Professor W. P. Rogers. Advisory committees are responsible for editorial matters affecting each individual journal, and members of the Board serve on appropriate journal committees.

The Royal Australian Chemical Institute collaborates in the publication of the *Australian Journal of Chemistry*, the Institute of Physics (Australian Branch) collaborates in the publication of the *Australian Journal of Physics*, and the Australian Veterinary Association and the Australian Institute of Agricultural Science collaborate in the publication of the *Australian Journal of Agricultural Research.*

The journals listed above are open to receive contributions of merit from research workers, irrespective of country or of the establishment to which they are attached. Many papers from workers in Australian universities and a limited number from overseas have been published.

The Organization's research results are published in the above journals, in its Bulletins, in the Technical Papers of its Divisions and Sections, and in special series such as the " Land Research " series and the " Soil Publication " series. Many research papers are also contributed by officers of the Organization to specialized scientific journals both in Australia and overseas.

A complete list of scientific papers published during the year by officers of the Organization will be found in Chapter XXXIV.

An arrangement has now been concluded whereby the Melbourne University Press will co-operate in the publication and distribution of various of the Organization's books. The first publication produced under this association is: " Timber Engineering Design Handbook ", compiled by three senior officers of the Timber Mechanics Laboratory, Division of Forest Products, and written for the use of Australian engineers and architects concerned with the design, fabrication, and erection of timber structures.

Other new publications issued by the Organization during the year include—

Scientific Serials in Australian Libraries.—This is the first issue of a loose-leaf publication supplementing and superseding the former Union Catalogue of Scientific and Technical Periodicals in the Libraries of Australia, edited by E. R. Pitt. It is designed to provide the research worker with an up-to-date finding list of scientific periodicals and serials in Australian libraries. With the volume in a loose-leaf form it will be possible at regular intervals to issue sheets amending and adding to the entries that it contains.

The Grasshoppers and Locusts (Acridoidea) of Australia, by Dr. James A. G. Rehn, Volume III.—This is the third volume of the monograph, and deals with portion of the subfamily Cyrtacanthacridinae of the family Acrididae.

3. AGRICULTURAL RESEARCH LIAISON SECTION.

The Agricultural Research Liaison Section has continued its efforts to bring the results of the Organization's agricultural research to the notice of extension officers and other interested persons. Liaison activities have been conducted by means of publications, conferences, and discussions with officers of the State Departments of Agriculture, and representatives of commercial institutions.

A review has been made of the relationships of the Section with the State Departments of Agriculture, which are responsible for extension services to the rural community. Arising from this review, it is hoped that closer understanding will be developed between the Organization and State Departments.

Two officers of the Section were transferred to Canberra to develop liaison with the Divisions located in Canberra responsible for agricultural research, and to stimulate more effective co-operative work on the Southern Tablelands project with the State Department of Agriculture.

(*a*) Rural Research in C.S.I.R.O.—The Section continued to publish the quarterly, *Rural Research in C.S.I.R.O.*, and Nos. 21-24 were issued during the year.

(*b*) *Southern Tablelands Co-operative Study.*—The co-operative study with the New South Wales Department of Agriculture has continued to assess existing and agricultural resources of the Southern Tablelands. Reports are being prepared on the characteristics of soils, climate, water resources, plant ecology, and farm management practices in the region. Reports on these subjects are in course of preparation and information on plant nutrition and fodder conservation has been assembled.

The study has already revealed a wide range of problems requiring further scientific inquiry, as well as having drawn attention to information which can be used immediately in extension work. A conference of representatives of organizations engaged in this co-operative study was held at Canberra in October, 1957. Constant liaison has been established between workers in complementary fields, and effort is being made to develop closer relationships between the separate disciplines contributing to the project.

(*c*) *Other Liaison Activities.*—The Section has continued its service work to those associated with the rural community. During the year some 2,000 enquiries were addressed to the Section relating to results of the Organization's research. In addition, assistance has been provided to Divisions in recording visits of overseas scientists and in organizing and participating in conferences.

The Section's design unit, in addition to normal production of *Rural Research in C.S.I.R.O., C.S.I.R.O. Industrial Research News,* and leaflets, also designed the Organization's stand at the Careers Exhibition, produced display material at the request of Divisions, and provided designs and illustrations for the Publications Section.

A film slide library is also being developed for the use of officers of the Organization.

4. INDUSTRIAL RESEARCH LIAISON SECTION.

This Section is concerned with those fields in which the Organization and secondary industry have interests in common. Among the functions of the Section are the promotion of the use in Australian industry of the results of the Organization's research, the fostering of new contacts between industry and the Divisions and Sections, and the encouragement of local industry to expand its own research activities.

Research financed by the Organization must chiefly be directed to the basic problems that affect wide sections of industry, and it is not always possible to tackle on an effective scale some problems that are of particular importance to specialized branches. In such cases, the industry concerned has on occasions been willing to provide financial support for an extension of the research programme of the Organization. Such collaboration has taken the form of sponsored research projects, several of which have been established in the Organization's laboratories with the active assistance of the Section. In this way specialized experience and research techniques, in some cases not available elsewhere in Australia, can be applied to problems that could not otherwise be included in the Organization's research programme.

A considerable number of technical enquiries is handled by the Section. Wherever possible each enquiry is placed with a laboratory or person having experience in the appropriate field, and the enquirer is able to receive direct help from those best qualified to give it. It is inevitable, however, that a proportion of enquiries are received on subjects in which no work is proceeding in Australia, and in these instances the technical literature is searched to provide information to assist the enquirer.

The Section's publication *C.S.I.R.O. Industrial Research News* has continued to present the results of the Organization's research in non-technical language. This is published at two-monthly intervals and describes research projects that are ready for industrial application; it is widely circulated throughout Australian industry. Its success in achieving its objectives can be inferred from the numerous requests from industry for additional copies, and from the large number of trade journals that reprint articles from the publication.

In the past few years, the number of patents arising out of research in the Organization has been growing, and a substantial body of patents is now held. The Section has been involved to an increasing extent in assistance to the Divisions on patenting problems and in all aspects of the industrial application of the Organization's patents. The Section, in collaboration with the Divisions concerned, is now responsible for promotion of patents, and this function constitutes an increasing proportion of the Section's effort. Each patent presents a different problem in exploitation, and a procedure which will be to the best advantage of the Organization and of Australian industry must be worked out in every case.

The methods of exploiting patents and promoting the industrial application of research results generally are being continually examined and developed by the Section. The Officer-in-charge accompanied a member of the Executive in visits to major research institutes and industrial laboratories in the United States in order to survey that country's methods of industrial promotion of the results of research. This survey is providing valuable information on American practice, much of which will be of assistance to the Section in its future operations.

5. OVERSEAS LIAISON.

The Organization has Scientific Liaison Offices in London and Washington as constituent units of the British Commonwealth Scientific Office (London), and the British Commonwealth Scientific Office (North America). These offices maintain close contact with overseas scientific developments and serve as centres for visitors and research students from the Organization and for other visiting scientists. The Chief Scientific Liaison Officers in London and Washington have represented Australia at scientific conferences in the United Kingdom, Europe, and the United States of America. The London office has materially assisted in the recruitment of research staff from the United Kingdom and European countries.

During the year, Mr. E. J. Drake, F.R.A.C.I., succeeded Mr. A. Shavitsky, B.Agr.Sc., as Chief Scientific Liaison Officer in London, and Mr. T. B. Paltridge, B.Sc. (Hons.), succeeded Mr. J. E. Cummins, B.Sc., M.S., as Chief Scientific Liaison Officer in Washington.

6. FILM UNIT.

During the year the following films were completed and released:—

Radio Astronomy in Australia—16 mm., colour, sound, screening time 19 min. Produced in collaboration with the Division of Radiophysics, the film deals with Australia's contribution to the modern science of radio astronomy.

Storms on the Sun—16 mm., colour, sound, screening time 18 min. In two parts, the film shows disturbances in the solar photosphere and the chromosphere as recorded and interpreted by the Division of Physics.

The SI-RO-SET Process—16 mm., b. and w., sound, screening time 11 min. Produced in collaboration with the Wool Textiles Research Laboratories, the film is intended primarily for the clothing trade. It describes the recently developed process for the permanent crease fixing of woollen trousers and pleated skirts. Foreign language versions have been prepared and issued by the International Wool Secretariat, London.

Advances in Cheddar Cheesemaking—16 mm., b. and w., sound, screening time 21 min. The film is designed primarily for the cheesemaking industry. It shows the traditional method of Cheddar cheesemaking and then describes a mechanical process recently developed in the Dairy Research Section.

Grapevine Pruning—16 mm., colour, sound, screening time 16 min. Produced in collaboration with the Commonwealth Research Station, Merbein, and the Agriculture Departments of New South Wales and Victoria, the film crystallizes 30 years of research and field observation on the pruning of grapevines along the River Murray.

War against the Rabbit—16 mm., colour, sound, screening time 21 min. First released in 1954, this film has been re-edited and modified to cover the use of " 1080 ", which has proved a more effective and better rabbit poison than strychnine previously used.

Films on the following subjects are due for early release:—

Mitosis—16 mm., colour, sound.

Macquarie Island Sanctuary—16 mm., colour, sound.

Sixty-eight prints of the Organization's films have been distributed during the year. Most of these were purchased by outside organizations and 24 were sent overseas. Two copies of all films were sent to the National Library, Canberra, and one copy to both the Australian Scientific Liaison Offices in London and in Washington. Extra copies have been purchased by the National Library for exchange with overseas scientific bodies.

The British Broadcasting Corporation has purchased silent copies of the three natural history films, *The Mutton Birds of Bass Strait, Penguins of Macquarie Island,* and *The Mallee Fowl.* These have been included, in part, in part, in a B.B.C. television programme.

The film *Mutton Birds of Bass Strait* was the basis of an A.B.C. national television session. Other film material was also supplied to television stations for inclusion in approved programmes.

The sum of $308 has already been received from royalties on the sale of copies of the film *Meiosis* by the International Film Bureau in the United States.

Wherever possible, borrowers are referred to the nearest film library in each State of Australia and overseas which holds our films. However, 470 film loans were made during the year through the Organization's own film library.

During the year a number of the Organization's films were screened at various film festivals—

Edinburgh Film Festival—*Penguins of Macquarie Island.*

XI. International Scientific Film Congress, Amsterdam—*Penguins of Macquarie Island, The Mallee Fowl.*

Melbourne Film Festival—*Radio Astronomy in Australia.*

XXXII. PERSONNEL OF COUNCIL AND COMMITTEES.

1. EXECUTIVE.

Sir Ian Clunies Ross, C.M.G., D.V.Sc., D.Sc., A.R.C.V.S., LL.D., F.A.A. (*Chairman*).
F. W. G. White, C.B.E., M.Sc., Ph.D. (*Deputy Chairman*).
S. H. Bastow, D.S.O., B.Sc., Ph.D. (*Chief Executive Officer*).
H. J. Goodes, O.B.E., B.A. (Term of office expired: 18th May, 1958.)
A. W. Coles.

2. ADVISORY COUNCIL.

Chairman.

Sir Ian Clunies Ross, C.M.G., D.V.Sc., D.Sc., A.R.C.V.S., LL.D., F.A.A.

Executive.

(See above.)

Chairmen of State Committees.

New South Wales—Professor H. R. Carne, D.V.Sc.
Victoria—Professor J. S. Turner, M.A., Ph. D., M.Sc., F.A.A.
Queensland—Professor W. V. Macfarlane, M.A., M.D.
South Australia—A. R. Callaghan, C.M.G., D.Phil., B.Sc., B.Sc.Agr.
Western Australia—Professor N. S. Bayliss, B.A., B.Sc., Ph.D., F.A.A.
Tasmania—T. A. Frankcomb.

Co-opted Members.

L. B. Bull, C.B.E., D.V.Sc., F.A.A.
Professor H. C. Forster, M.Agr.Sc., Ph.D.
D. R. Hawkes.
A. McCulloch, M.E.
M. A. Mawby, D.Sc., F.S.T.C.
B. Meecham, O.B.E.
W. W. Pettingell, B.Sc.
A. B. Ritchie, M.A.
E. P. S. Roberts.
Professor J. W. Roderick, M.A., Ph.D., M.Sc., F.A.A.
W. J. Russell, A.C.I.A.
E. M. Schroder.
W. Sloan.
H. B. Somerset, M.Sc.
Professor A. D. Trendall, M.A., Litt.D.
J. V. Vernon, B.Sc., Ph.D.
L. W. Weickhardt, M.Sc.
C. M. Williams, O.B.E.

3. STATE COMMITTEES.

New South Wales.

Professor H. R. Carne, D.V.Sc. (*Chairman*).
Emeritus Professor Sir Henry Barraclough, K.B.E., V.D., B.E., M.M.E.
Professor J. P. Baxter, O.B.E., B.Sc., Ph.D., F.A.A.
F. S. Bradhurst, D.Sc.
J N. Briton, B.Sc., B.E.
S. F. Cochran, F.A.S.A.
The Hon. O. McL. Falkiner, M.L.C.
W. R. Hebblewhite, B.E.
E. L. S. Hudson, Dip. For.

The Hon. Sir Norman Kater, M.L.C., M.B., Ch.M.
J. F. Litchfield.
Professor P. R. McMahon, M.Agr.Sc., Ph.D.
Professor J. R. A. McMillan, D.Sc.Agr., M.S.
Emeritus Professor Sir John Madsen, B.E., D.Sc., F.A.A.
J. Merrett.
C. St. J. Mulholland, B.Sc.
Professor D. M. Myers, B.Sc., D.Sc.Eng.
R. J. Noble, B.Sc.Agr., M.Sc., Ph.D.
R. P. Okeden.
J. G. Peake.
A. R. Penfold, A.S.T.C., F.R.A.C.I.
W. W. Pettingell, B.Sc.
Professor D. W. Phillips, B.Sc., Ph.D.
L. A. Pockley, B.V.Sc.
H. F. Prell.
Associate Professor F. H. Reuter, Ph.D.
Professor J. W. Roderick, M.A., Ph.D., M.Sc., F.A.A.
T. C. Roughley, B.Sc.
W. Sloan.
Sir John Tivey, B.A., B.Sc., B.E.
J. Vernon, B.Sc., Ph.D.
Emeritus Professor W. L. Waterhouse, C.M.G., M.C., D.Sc.Agr., D.I.C., F.A.A.
Emeritus Professor R D. Watt, M.A., B.Sc.
C. M. Williams, O.B.E.
A. J. Higgs, B.Sc. (*Secretary*).

Victoria.

Professor J. S. Turner, M.A., Ph.D., M.Sc., F.A.A. (*Chairman*).
R. S. Andrews, C.M.G., D.Sc., F.A.A.
D. T. Boyd, C.M.G.
L. B. Bull, C.B.E., D.V.Sc., F.A.A.
Sir Macfarlane Burnet, M.D., Ph.D., D.Sc., F.A.A., F.R.S.
S. B. Dickinson, M.Sc.
Professor H. C. Forster, M.Agr.Sc., Ph.D.
Professor J. N. Greenwood, D.Sc., M.Met.E.
Emeritus Professor E. J. Hartung, D.Sc.
H. Herman, D.Sc., M.M.E., B.C.E.
R. A. Hunt, D.S.O., B.C.E.
Associate Professor G. W. Leeper, M.Sc.
Emeritus Professor Sir Peter MacCallum, M.C., M.A., M.Sc., M.B., Ch.B.
I. M. McLennan, B.E.E.
Professor Sir Leslie Martin, C.B.E., Ph.D., F.A.A., F.R.S.
M. A. Mawby, D.Sc., F.S.T.C.
H. A. Mullett, I.S.O., B.Agr.Sc.
G. B. O'Malley, B.Met.E.
A. B. Ritchie, M.A.
Sir David Rivett, K.C.M.G., M.A., D.Sc., F.A.A., F.R.S.
D. E. Thomas, D.Sc.
Emeritus Professor Sir Samuel Wadham, M.A., LL.D., Dip.Agr.
W. E. Wainwright, A.S.A.S.M.
L. J. Weatherley, M.A.
L. W. Weickhardt, M.Sc.
Emeritus Professor H. A. Woodruff, B.Sc., M.R.C.S., L.R.C.P., M.R.C.V.S.
F. G. Nicholls, M.Sc. (*Secretary*).

Queensland.

Professor W. V. Macfarlane, M.A., M.D. (*Chairman*).
Professor T. K. Ewer, B.V.Sc., Ph.D.
B. Flewell-Smith, M.M.
V. Grenning.
W. A. Gunn, C.M.G.
R. L. Harrison.
Professor D. A. Herbert, D.Sc.
C. H. Jameson.
Professor T. G. H. Jones, D.Sc.
N. J. King.
A. McCulloch, M.E.
O. O. Madsen, M.L.A.
J. F. Meynink.

J. Michelmore.
I. W. Morley, B.M.E., B.Met.E.
O. E. J. Murphy, M.B., Ch.M.
E. P. S. Roberts.
Professor M. Shaw, M.E., M.Mech.E.
Professor W. Stephenson, B.Sc., Ph.D.
W. A. T. Summerville, D.Sc.
Professor L. J. H. Teakle, B.Sc.Agr., M.S., Ph.D.
S. A. Trout, M.Sc., Ph.D.
H. C. Urquhart, M.Sc.
R. Veitch, B.Sc.Agr., B.Sc.For.
Professor H. C. Webster, D.Sc., Ph.D.
W. Webster, B.V.Sc.
Professor F. T. M. White, B.Met.E., B.E.(Min.).
W. Young.
W. W. Bryan, M.Sc.Agr. (*Secretary*).

South Australia.

A. R. Callaghan, C.M.G., B.Sc., B.Sc.Agr., D.Phil. (*Chairman*).
A. J. Allen, F.R.A.C.I.
B. H. Bednall, B.Sc.
C. Haselgrove.
J. C. Hawker, B.A.
D. R. Hawkes.
O. H. Heinrich.
Professor L. G. H. Huxley, M.A., D.Phil., Ph.D., F.A.A.
R. N. McCulloch, M.B.E., D.Sc.Agr., B.Sc.
H. R. Marston, D.Sc., F.A.A., F.R.S.
Emeritus Professor Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.A.A., F.R.S.
Professor Sir Mark Mitchell, M.Sc.
F. W. Moorhouse, M.Sc.
The Hon. Sir Frank Perry, M.B.E., M.L.C.
Professor J. A. Prescott, C.B.E., D.Sc., F.A.A., F.R.S.
Professor E. A. Rudd, A.M., B.Sc.
W. L. Sanderson, O.B.E., M.C., C. de G.
E. M. Schroder.
A. M. Simpson, B.Sc.
Professor E. C. R. Spooner, B.E., D.Sc., D.Phil.
Professor J. G. Wood, Ph.D., D.Sc., F.A.A.
A. W. Peirce, D.Sc. (*Secretary*).

Western Australia.

Professor N. S. Bayliss, B.A., B.Sc., Ph.D., F.A.A. (*Chairman*).
D. W. Brisbane, M.I.C.E., M.I.Struct.E., M.I.E.Aust.
C. R. Bunning, B.C.E.
Professor C. J. Birkett Clews, B.Sc., Ph.D.
Professor K. L. Cooper, B.Sc., M.A.
A. J. Fraser.
B. J. Grieve, M.Sc., Ph.D., D.I.C.
A. C. Harris, B.Sc.
G. K. Baron-Hay, M.C., B.Sc.(Agric.).
Sir Edward Lefroy.
A. A. McLeod, M.Aust.I.M.M., M.A.I.M.E.
B. Meecham, O.B.E.
Professor R. T. Prider, B.Sc., Ph.D.
Emeritus Professor A. D. Ross, C.B.E., M.A., D.Sc.
H. P. Rowledge, F.R.A.C.I.
W. J. Russell, A.C.I.A.
L. W. Samuel, B.Sc., Ph.D.
G. L. Sutton, C.M.G., D.Sc.(Agric.).
D. O. Temby, B.E.
Professor E . J. Underwood, B.Sc.(Agric.), Ph.D., F.A.A.
Professor H. Waring, M.Sc., D.Sc., F.A.A.
R. P. Roberts, M.Sc.(Agric.) (*Secretary*).

Tasmania.

T. A. Frankcomb (*Chairman*).
Professor H. N. Barber, M.A., Ph.D.
L. R. S. Benjamin, F.R.A.C.I.
K. Brodribb.
W. Bryden, Ph.D., M.Sc., B.A.
A. H. Crane, B.Sc., M.For.
F. H. Foster, B.C.E.
F. W. Hicks, I.S.O., Q.D.A.
S. L. Kessell, M.B.E., M.Sc., Dip.For.
N. S. Kirby, B.E.
A. W. Knight, M.E., B.Sc., B.Com.
F. H. Peacock.
The Hon. Sir Rupert Shoobridge.
H. B. Somerset, M.Sc.
P. R. Stone.
D. Martin, D.Sc. (*Secretary*).

4. COMMITTEE OF REVIEW—AGRICULTURAL AND PASTORAL PROBLEMS.

Sir Ian Clunes Ross, C.M.G., D.V.Sc., LL.D., D.Sc., A.R.C.V., F.A.A., C.S.I.R.O. (*Chairman*).
C. S. Christian, B.Sc.Agr., M.S., Division of Land Research and Regional Survey, C.S.I.R.O.
O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S., Division of Plant Industry, C.S.I.R.O.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R.O.
H. R. Marston, D.Sc., F.A.A., F.R.S., Division of Biochemistry and General Nutrition, C.S.I.R.O.
A. J. Nicholson, D.Sc., F.A.A., Division of Entomology, C.S.I.R.O.
F. N. Ratcliffe, O.B.E., B.A., Wildlife Survey Section, C.S.I.R.O.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.O.
W. Ives, M.Ec., C.S.I.R.O. (*Secretary*).

5. COMMONWEALTH RESEARCH STATION, MERBEIN—TECHNICAL COMMITTEE.

L. A. T. Ballard, M.A., M.Agr.Sc., Ph.D., Division of Plant Industry, C.S.I.R.O.
C. Barnard, D.Sc., Division of Plant Industry, C.S.I.R.O.
J. R. Gordon, Commonwealth Dried Fruits Control Board.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.O.
F. Penman, M.Sc., Commonwealth Research Station, C.S.I.R.O., Merbein (*Secretary*).

6. COMMONWEALTH RESEARCH STATION, MERBEIN—CONSULTATIVE COMMITTEE.

J. R. Gordon, Growers' Representative, Mildura and Irymple (*Chairman*).
L. W. Andrew, Growers' Representative, South Australian River Council of A.D.F.A.
G. Black, Growers' Representative, Robinvale.
F. T. Bowman, Ph.D., M.Sc.Agr., H.D.A., Department of Agriculture, New South Wales.
J. Brown, Swan Hill Irrigators' Research Committee.
A. E. Cameron, Mildura District Citrus Growers' Association.
R. A. Cant, B.Agr.Sc., Department of Agriculture, South Australia.
J. Clift, Packers' Representative.
D. W. Cockroft, Growers' Representative, Mid-Murray.
C. E. Cole, B.Agr.Sc., Department of Agriculture, Victoria.
R. Drummond, B.C.E., State Rivers and Waters Supply Commission, Victoria.
W. V. Ford, Packers' representative.
W. B. Hawson, Growers' Representative, First Mildura Irrigation Trust.
A. E. Hazel, Growers' Representative, Red Cliffs.
S. Heaysman, Growers' Representative, Coomealla.
T. Hill, Growers' Representative, Curlwaa.
G. Hobson, Growers' Representative, Mid-Murray.
F. J. Hollins, Growers' Representative, Wakool.
H. Jackson, Growers' Representative, Wakool.
J. H. Lapthorne, Growers' Representative, Merbein.
T. C. Miller, B.Agr.Sc., Department of Agriculture, South Australia.

W. I. Nankivell, B.Agr.Sc., Department of Agriculture, Victoria.
F. S. Oldham, Department of Agriculture, New South Wales.
F. Penman, M.Sc., Commonwealth Research Station, C.S.I.R.O., Merbein.
R. C. Polkinghorne, Growers' Representative, Mid-Murray.
A. Seekamp, Growers' Representative, Loxton Agricultural Bureau.
J. V. Seekamp, B.Agr.Sc., Growers' representative, South Australian River Council of A.D.F.A.
J. L. Showell, Growers' Representative, Renmark Irrigation Trust.
A. L. Tisdall, M.Agr.Sc., State Rivers and Water Supply Commission.
D. V. Walters, M.Agr.Sc., Commonwealth Research Station, C.S.I.R.O., Merbein (*Secretary*).

7. IRRIGATION RESEARCH STATION, GRIFFITH—TECHNICAL COMMITTEE.

H. N. England, B.Sc., Water Conservation and Irrigation Commission, New South Wales.
O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S., Division of Plant Industry, C.S.I.R.O.
F. Penman, M.Sc., Commonwealth Research Station, C.S.I.R.O., Merebein.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.O.
V. C. Williams, Irrigation Research and Extension Committee.

8. IRRIGATION RESEARCH AND EXTENSION COMMITTEE (MURRIMBIDGEE IRRIGATION AREAS).

V. C. Williams, Griffith Producers' Co-operative Society, Rice Marketing Board of New South Wales (*Chairman*).
A. E. Bowmaker, Ricegrowers' Association of Australia, Leeton.
S. J. Bowyer, Rural Bank of New South Wales, Sydney.
H. V. Chaseling, Ricegrowers' Association of Australia, Griffith.
G. M. Clark, Yenda Producers' Co-operative Society, Yenda.
E. S. Clayton, H.D.A., Soil Conservation Service of New South Wales, Sydney.
H. Cooke, Private Industry, Griffith.
G. A. Crawford, H.D.A., New South Wales Department of Agriculture, Leeton.
C. A. Davidge, M.I.A. District Council of Extension Groups, Yenda.
L. C. Davidson, Leeton District Citrus Growers' Association, Leeton.
H. N. England, B.Sc., Water Conservation and Irrigation Commission of New South Wales, Sydney.
M. N. Errey, Leeton Fruitgrowers' Co-operative Society, Leeton.
S. Flint, B.Sc.Agr., Water Conservation and Irrigation Commission of New South Wales, Leeton.
E. R. Hoare, B.Sc., M.I.E.E., Irrigation Research Station, C.S.I.R.O., Griffith.
C. R. Hood, H.D.A., New South Wales Department of Agriculture, Leeton.
H. J. Hynes, D.Sc.Agr., M.Sc., New South Wales Department of Agriculture, Sydney.
B. G. Lowe, Leeton Co-operative Cannery, Leeton.
R. J. McCleary, M.I.A. Vegetable Growers' Association, Leeton.
K. B. Macfarlane, Water Conservation and Irrigation Commission of New South Wales, Leeton.
A. D. Mackellor, Ricegrowers' Co-operative Mills, Leeton.
F. J. McKirdy, Rural Bank of New South Wales, Leeton.
J. R. A. McMillan, D.Sc.Agr., M.S., University of Sydney.
L. F. Myers, M.Agr.Sc., Regional Pastoral Laboratory, C.S.I.R.O., Deniliquin.
F. Penman, M.Sc., Irrigation Research Stations, C.S.I.R.O., Merbein and Griffith.
H. W. Raphael, M.I.A. District Council of Extension Groups, Griffith.
R. Sainty, M.I.A. District Council of Extension Groups, Griffith.
C. E. Sharam, Ricegrowers' Association of Australia, Griffith.
A. H. Skepper, H.D.A., New South Wales Department of Agriculture, Leeton.
W. F. Townsend, Producers' Co-operative Distributing Society, Leeton.
A. J. Grassby (*Secretary-Treasurer*).

9. REGIONAL PASTORAL LABORATORY, DENILIQUIN—TECHNICAL COMMITTEE.

O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S., Division of Plant Industry, C.S.I.R.O.
H. N. England, B.Sc., Water Conservation and Irrigation Commission, New South Wales.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R.O.
T. J. Marshall, M.Agr.Sc., Ph.D., Division of Soils, C.S.I.R.O.
H. R. Marston, D.Sc., F.A.A., F.R.S., Division of Biochemistry and General Nutrition, C.S.I.R.O.
A. Morgan, B.Agr.Sc., Department of Agriculture, Victoria.
F. Penman, M.Sc., Commonwealth Research Station, C.S.I.R.O., Merbein.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.O.
A. L. Tisdall, M.Agr.Sc., State Rivers and Water Supply Commission, Victoria.
A. J. Vasey, B.Agr.Sc., Division of Animal Health and Production, C.S.I.R.O.
C. K. Vears, B.Sc.Agr., Department of Agriculture, New South Wales.
L. F. Myers, M.Agr.Sc., Regional Pastoral Laboratory C.S.I.R.O., Deniliquin (*Secretary*).

10. REGIONAL PASTORAL LABORATORY, DENILIQUIN—CONSULTATIVE COMMITTEE.

O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S., Division of Plant Industry, C.S.I.R.O.
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F. I. Bolton, Water Conservation and Irrigation Commission, New South Wales.
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T. L. Bull, Narrandera, New South Wales.
E. R. Ennals, Cobram Irrigation District, Victoria.
A. Morgan, B.Agr.Sc., Department of Agriculture, Victoria.
H. J. Robinson, "Merino Park", Wakool, New South Wales.
A. L. Tisdall, M.Agr.Sc., State Rivers and Water Supply Commission, Victoria.
C. K. Vears, B.Sc.Agr., Department of Agriculture, New South Wales.
J. Woodside, Boree Plains, Benerembah Irrigation District, Griffith, New South Wales.
L. F. Myers, M.Agr.Sc., Regional Pastoral Laboratory, C.S.I.R.O., Deniliquin (*Secretary*).

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Professor G. L. McClymont, B.V.Sc., Ph.D., University of New England.
M. A. McDonald, H.D.A., Department of Agriculture, New South Wales.
R. B. Madgwick, M.Ec., D.Phil., University of New England.
Professor A. F. O'Farrell, B.Sc., A.R.C.S., F.R.E.S., University of New England.
R. Roe, B.Sc. (Agric.), Division of Plant Industry, C.S.I.R.O.
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A. G. Brett, Graziers' Association of New South Wales.
A. W. Cameron, Graziers' Association of New South Wales.
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J. Ferris, Australian Primary Producers' Union.
G. E. Forster, Graziers' Association of New South Wales.
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I. K. Johnstone, D.V.Sc., Coopted member.
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A. Weir, Australian Primary Producers' Union.
A. W. Weller, Australian Primary Producers' Union.
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W. Webster, B.V.Sc., Department of Agriculture and Stock, Queensland.
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15. ADVISORY COMMITTEE ON FRUIT COOL STORAGE INVESTIGATIONS IN NEW SOUTH WALES.

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Professor R. L. Crocker, M.Sc., Ph.D., University of Sydney.
J. K. Long, B.Sc.Agr., Department of Agriculture, New South Wales.
R. N. Robertson, B.Sc., Ph.D., F.A.A., Division of Food Preservation and Transport, C.S.I.R.O.
R. B. Withers, M.Sc., Dip.Ed., Division of Food Preservation and Transport, C.S.I.R.O. (*Secretary*).

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F. Melville, B.Sc., Department of Agriculture, Western Australia.
T. C. Miller, B.Sc.(Agric.), Department of Agriculture, South Australia.
T. D. Raphael, M.A., Dip. Hort.(Cantab.), Department of Agriculture, Tasmania.
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S. A. Trout, M.Sc., Ph.D., Department of Agriculture and Stock, Queensland.
R. B. Withers, M.Sc., Dip.Ed., Division of Food Preservation and Transport, C.S.I.R.O. (*Secretary*).

17. COMMITTEE FOR CO-ORDINATION OF RESEARCH ON FRUIT AND VEGETABLE PROCESSING.

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J. A. Holbeche, H.D.A., Department of Agriculture, New South Wales.
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W. I. Nankivell, B.Agr.Sc., Department of Agriculture, Victoria.
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R. E. Banks, B.Sc.(Eng.), Building Research Liaison Service, Melbourne.
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K. Hopkins, Associated Fibrous Plaster Manufacturers of Australia.
A. C. Mitchinson, Associated Fibrous Plaster Manufacturers of Australia.
M. J. Ridge, M.Sc., Division of Building Research, C.S.I.R.O.
E. A. Willis, M.L.A., Associated Fibrous Plaster Manufacturers of Australia.
J. R. Barned, B.Sc., Division of Building, C.S.I.R.O. (*Secretary*).

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D. W. Griffiths, Victorian Chamber of Manufactures.
E. Haimann, Dr. Sc., Techn.Chem.E., Chamber of Manufactures of New South Wales.
J. Hesketh, F.R.A.C.I., Victorian Chamber of Manufactures.
E. Hoffmann, Dr.Phil., Division of Building Research, C.S.I.R.O.
J. R. Barned, B.Sc., Division of Building Research, C.S.I.R.O. (*Secretary*).

XXXIII. STAFF.

The following is a list of the staff of the Organization as at 30 June, 1958. The list does not include clerical staff, typists, technical officers, technical assistants, and miscellaneous workers.

1. HEAD OFFICE.

(Head-quarters: 314 Albert-street, East Melbourne.)
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Deputy Chairman—F. W. G. White, C.B.E., M.Sc., Ph.D.
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Research Secretary (Scientific Services)—F. G. Nicholls, M.Sc.
Research Secretary (Physical Sciences)—G. B. Gresford, B.Sc., A.R.M.T.C.
Research Secretary (Biological Sciences)—W. Ives, M.Ec.
Secretary (Finance and Supplies)—M. G. Grace, A.A.S.A.
Assistant Research Secretary (Staff)—D. T. C. Gillespie, M.Sc.
Assistant Research Secretary (Biological Science)—P. F. Butler, M.Ag.Sc.
Senior Research Officer—W. F. Evans, B.Sc.
Senior Research Officer—W. M. Balding, B.Sc.
Experimental Officer—Miss J. Dunstone, B.Sc., Dip.Ed.
Experimental Officer—A. K. Klingender, B.Sc.
Experimental Officer—B. E. Mummery, B.Sc.
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  Senior Research Officer—R. W. Crabtree, B.Sc.
  Senior Research Officer—Miss M. Walkom, B.A.
  Research Officer—L. A. Bennett, B.Sc.
  Research Officer—Miss L. F. Plunkett, B.Sc.
  Research Officer—G. J. Wylie, B.A.(Hons.), B.Sc.
  Experimental Officer—R. Schoenfeld, B.Sc.
  Experimental Officer—R. L. Aujard, B.Sc.
  Experimental Officer—G. A. Forster, B.A., B.Sc.

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Chief Librarian—Miss B. C. L. Doubleday, M.A.
Scientific Librarian—Mrs. J. Barker, B.Sc.
Scientific Librarian—Miss J. A. Conochie, B.Sc.
Scientific Librarian—Miss L. J. Davey, B.Sc.
Scientific Librarian—Miss J. C. Kahan, B.Sc. (at Perth).
Scientific Librarian—Miss H. M. Storie, B.Sc., F.R.M.T.C.
Librarian—Miss P. Prendergast, B.A.
Union Catalogue of Periodicals, Editor—Miss A. L. Kent.

Accounts—
Accountant—D. J. Bryant, A.A.S.A.

Finance—
Assistant Secretary (Finance and Supplies)—R. W. Viney, A.A.S.A., A.C.I.S.

Stock Records—
J. M. Short, A.A.S.A., A.C.I.S.

Orders and Transport—
V. H. Leonard, J.P.

Staff—
Staff Relations Officer—L. G. Peres, B.Ec.
Senior Staff Officer—J. Coombe.

Records—
P. Knuckey.

Publications—
T. R. Hunter.

Liaison Overseas—
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Chief Scientific Liaison Officer—E. J. Drake, F.R.A.C.I.
Senior Research Officer—A. B. Hackell, B.Agr.Sc.
Senior Research Officer—R. C. Richardson, B.E.

Washington—
Chief Scientific Liaison Officer—T. B. Paltridge, B.Sc.(Hons.).

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Translator—Miss M. J. Hardy, B.A. (Hons.).
Translator—C. Wouters, Ph.D.(Lit.) (at Sydney).
Translator—P. A. Kazakov, LL.B. (at Sydney) (part-time).

Film Unit—
Senior Research Officer—S. T. Evans, B.Sc.

Architectural—
Architect—W. R. Ferguson, B.E.

2. SECRETARIES OF STATE COMMITTEES.

New South Wales—
A. J. Higgs, B.Sc.(Hons.), Division of Radiophysics, University of Sydney.

Victoria—
F. G. Nicholls, M.Sc., 314 Albert-street, East Melbourne.

Queensland—
W. W. Bryan, M.Sc.Agr., Plant and Soils Laboratory, Brisbane.

South Australia—
A. W. Peirce, D.Sc., Division of Biochemistry and General Nutrition, University of Adelaide.

Western Australia—
R. P. Roberts, M.Sc.(Agric.), Department of Agriculture, Perth.

Tasmania—
D. Martin, D.Sc., "Stowell", Stowell-avenue, Hobart.

3. AGRICULTURAL RESEARCH LIAISON SECTION.

(Head-quarters: 34 Albert-street, East Melbourne.)

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Principal Research Officer—K. Loftus Hills, M.Agr.Sc.
Senior Research Officer—Mrs. J. Tully, B.Sc.(Hons.), Ph.D. (seconded to University of Melbourne).
Research Officer—J. L. Dillon, B.Sc.Agr. (on leave).
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Experimental Officer—J. J. Lenaghan, B.Agr.Sc., M.S.
Experimental Officer—G. F. Smith, M.A.
Experimental Officer—N. L. Tyshing, B.Sc.Agr.

At Canberra Office—
Senior Research Officer—A. F. Gurnett-Smith, B.Agr.Sc.
Experimental Officer—K. D. Woodyer, B.Sc.Agr.

4. ANIMAL GENETICS SECTION.

(Head-quarters: University of Sydney.)

Officer-in-charge—J. M. Rendel, B.Sc., Ph.D.
Principal Research Officer—A. S. Fraser, M.Sc., Ph.D.
Senior Research Officer—W. R. Sobey, B.Sc., Ph.D
Senior Research Officer—G. W. Grigg, M.Sc., Ph.D.
Senior Research Officer—H. I. Hoffman, M.Sc., Ph.D.
Research Officer—B. L. Sheldon, B.Agric.Sc.(Hons.).
Research Officer—T. Nay.
Experimental Officer—K. E. Turnbull, B.A.
Experimental Officer—Miss B. M. Kindred, B.Sc.(Hons.).
Experimental Officer—Miss M. J. Burford, B.Sc.

5. DIVISION OF ANIMAL HEALTH AND PRODUCTION.

(Head-quarters: Cnr. Flemington-road and Park-street, Parkville, Melbourne.)

At Divisional Head-quarters, Melbourne—
Chief—D. A. Gill, M.R.C.V.S., D.V.S.M.
Divisional Secretary—A. J. Vasey, B.Agr.Sc.

At Animal Health Research Laboratory, Melbourne—
Assistant Chief of Division and Officer-in-charge—T. S. Gregory, D.V.Sc., Dip.Bact.
Assistant Chief of Division—A. W. Turner, O.B.E., D.Sc., D.V.Sc., F.A.A.
Laboratory Secretary—J. M. McMahon, B.Com.
Senior Research Fellow—L. B. Bull, C.B.E., D.V.Sc., F.A.A.
Senior Principal Research Officer—A. T. Dick, D.Sc.
Principal Research Officer—D. Murnane, D.V.Sc.
Principal Research Officer—R. H. Watson, D.Sc.Agr.
Senior Research Officer—A. T. Dann, M.Sc.
Senior Research Officer—I. D. B. Newsam, Ph.D., M.R.C.V.S.
Senior Research Officer—J. E. Peterson, B.V.Sc.
Senior Research Officer—A. W. Rodwell, M.Sc., Ph.D.
Research Officer—J. B. Bingley, D.A.C.
Research Officer—G. S. Cottew, B.Sc.
Research Officer—J. F. Eadie, B.Sc.
Research Officer—Miss V. E. Hodgetts, B.Sc.
Research Officer—P. Plackett, B.A.
Research Officer—H. M. Radford, B.Sc.
Experimental Officer—S. H. Buttery, B.Sc.
Experimental Officer—Miss C. E. Eales, B.Sc.
Experimental Officer—Miss M. J. Monsbourgh, B.Sc.
Experimental Officer—Miss E. M. Elder, B.Agr.Sc.
Scientific Librarian—Miss F. V. Murray, M.Sc.

At Poultry Research Centre, Werribee, Victoria—

Principal Research Officer and Officer-in-charge—F. Skaller, M.Agr.Sc., B.Com.
Senior Research Officer—J. A. Morris, B.Sc.Agr. (Hons.), Ph.D.
Senior Research Officer—F. E. Binet, M.D.
Research Officer—T. E. Allen, B.Sc.
Experimental Officer—Miss L. W. I. Bobr, M.Sc. (Agr.).

At McMaster Animal Health Laboratory, Sydney—

Officer-in-charge—D. F. Stewart, D.V.Sc., Dip.Bact.
William McIlrath Fellow in Animal Husbandry—M. C. Franklin, M.Sc., Ph.D.
Senior Principal Research Officer—H. McL. Gordon, B.V.Sc.
Principal Research Officer—Miss H. A. Newton Turner, B.Arch.
Senior Research Officer—N. P. H. Graham, B.V.Sc.
Senior Research Officer—A. A. Dunlop, M.Agr.Sc., Ph.D.
Senior Research Officer—M. D. Murray, B.Sc. (Vet.Sci.), F.R.C.V.S.
Senior Research Officer—R. I. Sommerville, M.Sc. Agr.(Hons.).
Research Officer—P. K. Briggs, B.Sc.Agr.(Hons.).
Research Officer—C. H. Gallagher, B.V.Sc., Ph.D.
Research Officer—I. G. Pearson, B.V.Sc.
Research Officer—L. E. A. Symons, B.V.Sc.
Research Officer—Mrs. N. B. Carter, B.Sc.
Research Officer—J. J. Thomas, B.V.Sc.
Research Officer—D. S. Roberts, B.V.Sc.
Research Officer—B. A. Panaretta, B.V.Sc. (on study leave).
Research Officer—G. M. Tallis, M.Sc., Ph.D.
Ian McMaster Fellow—I. W. Parnell, B.A., Ph.D., F.R.S.E.
Ian McMaster Fellow—E. J. L. Soulsby, M.A., Ph.D., M.R.C.V.S., D.V.S.M.
Experimental Officer—K. J. Farrington, B.Sc., A.S.T.C.
Experimental Officer—J. C. Boray, D.V.M.
Experimental Officer—S. S. Y. Young, B.Agr.Sc. (on study leave).
Experimental Officer—T. J. Grainger, B.Sc.
Scientific Librarian—Miss A. G. Culey, M.Sc.
Laboratory Secretary—H. H. Wilson.

At Sheep Biology Laboratory, Prospect, New South Wales—

Assistant Chief of Division and Officer-in-charge—I. W. McDonald, B.V.Sc., B.Sc., Ph.D.
Technical Secretary—J. H. Elliott, B.Sc.(Hons.).
Principal Research Officer—K. A. Ferguson, B.V.Sc., Ph.D.
Principal Research Officer—J. C. D. Hutchinson, M.A.
Principal Research Officer—G. R. Moule, D.V.Sc.
Principal Research Officer—R. L. Reid, B.Sc.Agr. (Hons.), Ph.D.
Principal Research Officer—P. G. Schinckel, B.V.Sc.
Senior Research Officer—G. Alexander, M.Agr.Sc.
Senior Research Officer—A. W. H. Braden, B.Sc., Ph.D.
Senior Research Officer—A. M. Downes, M.Sc.
Senior Research Officer—A. G. Lyne, B.Sc., Ph.D.
Senior Research Officer—B. F. Short, M.Agr.Sc., Ph.D.
Research Officer—A. H. Brook, B.V.Sc.
Research Officer—J. P. Hogan, B.Sc.Agr.(Hons.), Ph.D.
Research Officer—H. R. Lindner, B.V.Sc.
Research Officer—P. J. Reis, B.Sc.Agr.(Hons.).
Research Officer—A. L. C. Wallace, B.Sc.
Research Officer—A. C. Warner, B.Sc., Dip.Microbiol., Ph.D.
Research Officer—R. H. Weston, B.Sc.Agr.(Hons.).
Research Officer—Miss M. M. Wodzicka, M.Agr.Sc.
Experimental Officer—J. W. U. Beeston, M.B.E., A.S.T.C.
Experimental Officer—R. E. Chapman, B.Sc.App. (Hons.).
Experimental Officer—J. W. Bennett, B.Sc.
Experimental Officer—Miss B. Burnett, B.Sc.Agr.
Experimental Officer—Mrs. J. M. Date, B.Sc.Agr.
Experimental Officer—Miss J. I. Davies, B.Sc. (Hons.).
Experimental Officer—Miss J. K. Elder, B.Sc.
Experimental Officer—Miss M. J. Heideman, B.A.
Experimental Officer—Miss S. M. Kemeny, B.Sc.Agr.
Experimental Officer—S. C. Mills, B.Sc., A.S.T.C.
Experimental Officer—W. T. Outch, A.S.T.C.
Experimental Officer—L. F. Sharry, A.R.M.T.C.
Experimental Officer—A. R. Till, B.Sc.
Scientific Librarian—G. G. Allen, M.A.

At Regional Pastoral Laboratory, Armidale, New South Wales—

Executive Officer to Research Committee—J. F. Barrett, B.V.Sc.
Senior Research Officer—W. H. Southcott, B.V.Sc.
Senior Research Officer—L. J. Lambourne, M.Sc.
Experimental Officer—J. M. H. George, B.Sc.Agr.
Experimental Officer—D. B. Muirhead.

At McMaster Field Station, Badgery's Creek, New South Wales—

Officer-in-charge—R. H. Hayman, M.Agr.Sc.
Senior Research Officer—D. F. Dowling, B.V.Sc., B.Sc., Ph.D.
Research Officer—J. M. Doney, B.Sc.(Hons.), Ph.D.
Experimental Officer—Y. S. Pan, B.Sc.Agr.

At Veterinary Parasitology Laboratory, Yeerongpilly, Queensland—

Officer-in-charge—F. H. S. Roberts, D.Sc.
Acting Officer-in-charge—R. F. Riek, B.V.Sc., M.Sc.
Senior Research Officer—P. H. Durie, M.Sc.
Research Officer—K. C. Bremner, M.Sc.
Research Officer—P. Elek, LL.D., B.V.Sc.
Experimental Officer—R. K. Keith, A.R.A.C.I., Dip.Ind.Chem.

At National Cattle Breeding Station, "Belmont", Rockhampton, Queensland—

Officer-in-charge—J. F. Kennedy, M.Agr.Sc.
Senior Research Officer—H. G. Turner, B.Agr.Sc., M.A.
Experimental Officer—R. W. Hewetson, B.V.Sc.
Experimental Officer—G. T. French, B.V.Sc.
Experimental Officer—A. V. Schleger, B.Sc.

At National Field Station, "Gilruth Plains", Cunnamulla, Queensland—

Officer-in-charge—C. H. S. Dolling, B.Agr.Sc.
Experimental Officer—R. W. Moore, B.Agr.Sc.

At Western Australian Department of Agriculture, Animal Health and Nutrition Laboratory, Nedlands, Western Australia—

Senior Research Officer—A. B. Beck, M.Sc.

At Institute of Agriculture, University of Western Australia, Nedlands, Western Australia—

Senior Research Officer—E. Munch-Petersen, M.Sc., B.A.

6. DIVISION OF BIOCHEMISTRY AND GENERAL NUTRITION.

(Head-quarters: University of Adelaide.)

Chief—H. R. Marston, D.Sc., F.A.A., F.R.S.
Senior Principal Research Officer—D. S. Riceman, M.Sc., B.Ag.Sc.
Principal Research Officer—Miss M. C. Dawbarn, M.Sc.
Principal Research Officer—F. V. Gray, M.Sc.
Principal Research Officer—I. G. Jarrett, M.Sc.

Principal Research Officer—G. B. Jones, M.Sc.
Principal Research Officer—H. J. Lee, M.Sc.
Principal Research Officer—J. A. Mills, M.Sc., Ph.D.
Principal Research Officer—A. W. Peirce, D.Sc.
Senior Research Officer—Miss S. H. Allen, B.Sc.
Senior Research Officer—L. J. Frahn, M.Sc., Ph.D.
Senior Research Officer—A. F. Pilgrim, B.Sc.
Senior Research Officer—R. M. Smith, B.Sc.
Senior Research Officer—R. A. Weller, B.Sc.
Research Officer—W. W. Forrest, B.Sc., Ph.D.
Research Officer—R. E. Kuchel, B.Sc.
Research Officer—B. J. Potter, M.Sc.
Research Officer—Mrs. D. C. Roder, M.Sc.
Research Officer—D. J. Walker, B.Sc., Ph.D.
Experimental Officer—A. C. Blaskett, B.Sc.
Experimental Officer—W. D. Dewey.
Experimental Officer—O. H. Filsell, B.Sc.
Experimental Officer—H. Hewett Jones, R.D.A.
Experimental Officer—W. S. Osborne White, B.Sc.
Experimental Officer—V. A. Stephen.
Experimental Officer—J. O. Wilson (part-time).

7. Division of Building Research.

(Head-quarters: Graham-road, Highett, Victoria.)

Administration—
Chief—I. Langlands, M.Mech.E., B.E.E.
Technical Secretary—J. R. Barned, B.Sc., A.R.M.T.C.
Editor—I. C. H. Croll, B.Sc.
Senior Drafting Officer—W. Maier, Dip.Ing.

Information and Library—
Senior Research Officer—R. C. McTaggart, B.Sc.
Experimental Officer—E. M. Coulter, M.Ag.Sc.
Librarian—Miss L. W. Power.

Mechanics and Physics of Materials—
Senior Research Officer—F. A. Blakey, B.E.(Hons.), Ph.D.
Senior Research Officer—L. Finch, B.Arch., B.Sc., Ph.D.
Experimental Officer—W. H. Taylor, M.C.E.
Experimental Officer—R. E. Lewis, B.Sc.(Hons.).
Experimental Officer—E. N. Mattison.
Experimental Officer—B. Kroone, D.R.S.
Experimental Officer—F. D. Beresford, F.R.M.T.C.
Experimental Officer—J. J. Russell, B.Sc.

Masonry Investigations—
Principal Research Officer—J. S. Hosking, M.Sc., Ph.D.
Principal Research Officer—W. F. Cole, M.Sc., Ph.D.
Senior Research Officer—H. V. Hueber, Dr.Phil.
Senior Research Officer—R. D. Hill, B.Sc., B.Com.
Research Officer—Miss A. A. Milne, B.Sc., Ph.D.
Experimental Officer—Miss N. M. Rowland, F.R.M.T.C.
Experimental Officer—A. E. Holland, A.R.M.T.C.
Experimental Officer—D. N. Crook, A.Sw.T.C.
Experimental Officer—C. L. Carrel, B.Sc.

Surfacing Materials Investigations—
Senior Research Officer—E. H. Waters, M.Sc.
Experimental Officer—J. E. Bright, B.Sc.
Experimental Officer—D. A. Powell, B.Sc.
Experimental Officer—G. F. Moss, B.Sc.
Experimental Officer—S. J. Way, B.Sc.

Architectural Physics—
Principal Research Officer—R. W. Muncey, M.E.E.
Principal Research Officer—W. K. R. Lippert, Dr.rer.nat.
Senior Research Officer—A. F. B. Nickson, M.Sc.
Research Officer—T. S. Holden, B.Sc.
Experimental Officer—P. Dubout, B.Sc.
Experimental Officer—J. S. Howard, B.E.
Experimental Officer—W. A. Davern, A.R.M.T.C.

Organic Materials Investigations—
Senior Research Officer—E. R. Ballantyne, B.Sc.
Research Officer—K. G. Martin, B.Sc.
Experimental Officer—J. W. Spencer, B.Sc.
Experimental Officer—N. G. Brown, A.M.T.C.

Fibrous Plaster Research—
Senior Research Officer—M. J. Ridge, M.Sc.

Paint on Plaster Investigation—
Senior Research Officer—E. Hoffman, Dr.Phil.

8. Canberra Laboratories, Administrative Office.

(The services of this office are common to the Divisions and Sections in Canberra.)

Senior Administrative Officer—K. J. Prowse.
Deputy Senior Administrative Officer—D. Banyard.
Accountant—E. E. Petersen.
Scientific Librarian—D. R. May, B.A., B.Sc.
Senior Librarian—P. Russell.
Librarian—Miss C. J. Maguire, B.A.
Librarian—Miss M. J. Morley, B.A.

9. Coal Research Section.

(Head-quarters: Delhi-road, North Ryde, New South Wales.)

Officer-in-charge—H. R. Brown, B.Sc.(Eng.)(Hons.).
Technical Secretary—K. F. Baker, M.Sc.Appl., D.Sc.Tech.
Principal Research Officer—J. D. Brooks, B.Sc.(Hons.).
Principal Research Officer—E. J. Greenhow, B.Sc. (Hons.), Ph.D.
Principal Research Officer—P. L. Waters, B.Sc.(Hons.), Ph.D.
Senior Research Officer—W. T. Cooper, B.Sc.(Hons.).
Senior Research Officer—R. A. Durie, M.Sc., Ph.D.
Senior Research Officer—G. L. Shires, M.E.
Research Officer—J. J. Batten, M.Sc. (overseas).
Research Officer—K. McG. Bowling, B.Sc., Ph.D.
Research Officer—A. Cameron, B.Sc.(Hons.), Ph.D.
Research Officer—W. R. Hesp, Dipl.Ing.Chem., D.Sc. Tech.
Research Officer—B. M. Lynch, M.Sc., Ph.D.
Research Officer—W. Kelly, B.Sc.(Hons.), Ph.D.
Research Officer—M. Kossenberg, Ph.D.
Research Officer—J. S. Shannon, B.Sc.(Hons.), Ph.D.
Research Officer—J. F. Stephens, M.Sc. (overseas).
Research Officer—S. Sternhell, M.Sc.
Research Officer—G. H. Taylor, M.Sc., Dr.rer.nat.
Research Officer—J. F. Wilshire, B.Sc.(Hons.), Ph.D.
Experimental Officer—M. S. Burns, M.Inst.F.
Experimental Officer—J. Szewczyk, Dipl.Ing.Chem.
Experimental Officer—F. Agus, A.M.Inst.F.
Experimental Officer—G. à Donau Szpindler, Dip.Ing., D.I.C.
Experimental Officer—J. P. F. Hennelly, B.Sc.
Experimental Officer—C. G. Macdonald, M.Sc.
Experimental Officer—R. Neronowicz, Dipl.Eng.
Experimental Officer—D. H. Philipp, B.Sc.
Experimental Officer—H. N. S. Schafer, B.Sc.(Hons.).
Experimental Officer—J. W. Smith, A.R.I.C.
Experimental Officer—W. O. Stacey, B.Sc.
Experimental Officer—J. N. Stephens, M.A.
Experimental Officer—Mrs. G. Sugowdz, M.Sc.
Experimental Officer—J. W. Sweeting, B.Sc.
Experimental Officer—A. Watts, A.S.M.B.
Experimental Officer—P. R. C. Goard, B.Sc.
Experimental Officer—Mrs. O. V. Molnar, Dipl.Chem. Eng.
Experimental Officer—S. St. J. Warne, B.Sc.
Librarian—Miss P. I. Ross, B.A.(Hons.)

10. Dairy Research Section.

(Head-quarters: Graham-road, Highett, Victoria.)

Officer-in-charge—G. D. Loftus Hills, B.Agr.Sc.
Technical Secretary—L. L. Muller, B.Sc.

Principal Research Officer—N. King, M.Sc.
Senior Research Officer—E. G. Pont, M.Sc.Agr.
Senior Research Officer—J. Conochie, B.Sc.(Agric.).
Senior Research Officer—J. Czulak, B.Sc.(Agric.), Dip. Bact.
Senior Research Officer—D. A. Forss, M.Sc.
Research Officer—J. W. Lee, Ph.D., B.Sc.(Hons.).
Research Officer—K. J. Turner, Ph.D., B.Sc.(Hons.).
Experimental Officer—A. J. Lawrence, B.Sc.
Experimental Officer—Miss B. M. P. Keogh, M.Sc.
Experimental Officer—R. Beeby, A.R.M.T.C.

11. Division of Electrotechnology.

(Head-quarters: National Standards Laboratory at the University of Sydney.)

Chief—F. J. Lehany, M.Sc.
Technical Secretary—R. C. Richardson, B.E. (overseas with A.S.L.O., London).
Senior Principal Research Officer—W. K. Clothier, B.Sc., M.E.
Senior Principal Research Officer—A. M. Thompson, B.Sc.
Principal Research Officer—R. J. Meakins, B.Sc., Ph.D., D.I.C.
Principal Research Officer—D. L. Hollway, B.E.E., M.Eng.Sc., D.Sc.(Eng.)
Principal Research Officer—J. S. Dryden, M.Sc., Ph.D., D.I.C.
Senior Research Officer—L. G. Dobbie, M.E.
Senior Research Officer—T. M. Palmer, Dipl.F.H.
Senior Research Officer—L. Medina, Dipl.Ing.
Senior Research Officer—D. L. H. Gibbings, B.E., B.Sc., Ph.D.
Senior Research Officer—D. W. Posener, M.Sc., Ph.D.
Senior Research Officer—D. G. Lampard, M.Sc., Ph.D.
Senior Research Officer—H. K. Welsh, M.Sc.
Research Officer—C. H. Miller, B.E., D.Phil.
Research Officer—G. J. A. Cassidy, B.E.E.
Research Officer—G. J. Johnson, B.Sc.(Hons.).
Research Officer—P. G. Harper, B.Sc.(Hons.), Ph.D.
Research Officer—W. E. Smith, B.Sc.
Experimental Officer—L. M. Mandl, Dipl.Ing., A.S.T.C.
Experimental Officer—H. A. Smith, A.S.T.C.
Experimental Officer—R. W. Archer, A.S.T.C.
Experimental Officer—F. C. Brown, A.S.T.C.
Experimental Officer—M. C. McGregor, A.S.T.C.
Experimental Officer—I. K. Harvey, A.S.T.C.
Experimental Officer—D. B. Armitage, B.Sc., B.E.
Experimental Officer—H. Bairnsfather.
Experimental Officer—H. C. Collins, A.S.T.C.
Experimental Officer—J. M. Melano, A.S.T.C.
Experimental Officer—J. S. Cook, M.Sc.
Experimental Officer—R. E. Holmes, A.S.T.C.
Experimental Officer—R. P. Hoffman, A.S.T.C.
Experimental Officer—W. H. Reid, A.S.T.C.
Experimental Officer—P. Buss, A.S.T.C.
Experimental Officer—J. Freiheiter, B.E.E.
Experimental Officer—A. W. Fleischmann, A.S.T.C.
Experimental Officer—D. F. P. Kelly, A.S.T.C.
Experimental Officer—P. I. Somlo, Dipl.E.E.
Experimental Officer—J. C. Coles, B.A., A.S.T.C.
Drafting Officer—T. H. Gruetzmacher.

12. Engineering Section.

(Head-quarters: Graham-road, Highett, Victoria.)

Officer-in-charge—R. N. Morse, B.Sc., B.E.
Electrical and Mechanical Engineer—F. G. Hogg, B.E.
Senior Research Officer—J. J. Kowalczewski, Dipl.Ing.
Senior Research Officer—J. H. McClelland, B.Sc., M.Agr.Sc.
Research Officer—M. Kovarik, Ing.
Research Officer—R. H. S. Riordan, B.E.E.
Experimental Officer—K. A. Robeson, B.Mech.E.
Experimental Officer—G. T. Stephens, Dip.Mech.Eng., Dip.Elec.Eng.
Experimental Officer—R. C. R. Johnston, B.Mech.E., M.Eng.Sc.
Experimental Officer—J. T. Czarnecki, Dipl.Ing.
Experimental Officer—D. W. Cunliffe, F.M.T.C.
Experimental Officer—L. G. Claxton, B.Mech.E., R.D.A.
Experimental Officer—W. R. W. Read.
Experimental Officer—T. D. Norwood, Dip.Mech.Eng., Dip.Elec.Eng.
Experimental Officer—E. R. Wilson, B.E.E., A.G.Inst. Tech.
Experimental Officer—D. Perczuk.
Drafting Officer—E. T. Davey.
Drafting Officer—H. L. Chapman.

13. Division of Entomology.

(Head-quarters: Canberra, Australian Capital Territory.)

At Canberra—
Administration—
Chief—A. J. Nicholson, D.Sc., F.A.A.
Assistant Chief—D. F. Waterhouse, D.Sc., F.A.A.
Technical Secretary—K. L. Taylor, B.Sc.Agr.

Population Dynamics—
Chief—A. J. Nicholson, D.Sc., F.A.A.

Field Population Studies—
Principal Research Officer—L. R. Clark, M.Sc.

Ecology of Orchard Pests—
Senior Research Officer—P. Geier, B.Sc.(Agr.), Ph.D.
Experimental Officer—A. Magassy, Dr.Agr.Sc.

Cockchafers and Eucalypt Defoliating Insects—
Senior Research Officer—P. B. Carne, B.Agr.Sc., Ph.D., D.I.C.

Locust Investigations—
Principal Research Officer—K. H. L. Key, D.Sc., Ph.D., D.I.C. (overseas).

Grasshopper Investigations—
Research Officer—D. P. Clark, B.Sc., Ph.D.

Pasture Caterpillars and Taxonomy of Lepidoptera—
Principal Research Officer—I. F. B. Common, M.A., M.Agr.Sc.

Taxonomy of Diptera—
Senior Research Officer—S. J. Paramonov, D.Sc.

Taxonomy of Hymenoptera—
Principal Research Officer—E. F. Riek, M.Sc.

Museum—
Research Officer—T. G. Campbell.

Physiology and Toxicology—
Assistant Chief—D. F. Waterhouse, D.Sc., F.A.A.
Principal Research Officer—D. Gilmour, M.Sc.
Principal Research Officer—R. H. Hackman, M.Sc., Ph.D.
Senior Research Officer—R. F. Powning, A.S.T.C., M.Sc.
Research Officer—A. R. Gilby, M.Sc., Ph.D.
Research Officer—L. B. Barton Browne, B.Sc., Ph.D. (overseas).
Experimental Officer—H. Irzykiewicz.
Experimental Officer—J. W. McKellar, B.Sc.
Experimental Officer—Mrs. M. M. Goldberg, B.Sc.

Virus Investigations—
Principal Research Officer—M. F. Day, B.Sc., Ph.D., F.A.A.
Research Officer—T. D. C. Grace, B.Sc. (overseas).
Experimental Officer—N. E. Grylls, D.D.A.

Insecticide Investigations—
Senior Research Officer—R. W. Kerr, B.Sc.

Biological Control—
Principal Research Officer—F. Wilson.
Research Officer—G. F. Bornemissza, Ph.D.

Termite Investigations—
Principal Research Officer—F. J. Gay, B.Sc., D.I.C.

Termites in Forest Trees—
Senior Research Officer—T. Greaves.

Grain Storage Investigations—
Principal Research Officer—S. W. Bailey, B.Sc., A.R.C.S.

Sheep Blowfly Ecology—
Principal Research Officer—K. R. Norris, M.Sc.

At Yeerongpilly, Queensland—
Cattle Tick Investigations—
Senior Research Officer—P. R. Wilkinson, M.A.
Senior Research Officer—W. J. Roulston, B.Sc. (overseas).
Experimental Officer—H. J. Schnitzerling, Dip.Ind. Chem.
Experimental Officer—C. A. Schunter, B.Sc.
Experimental Officer—B. F. Stone, Dip.Ind.Chem.

At Townsville, Queensland—
Cattle Tick Investigations—
Experimental Officer—K. L. S. Harley, B.Sc.

At Plant and Soils Laboratory, Brisbane—
Biological Control Investigations—
Senior Research Officer—G. O. Strides, B.Sc., Ph.D.

At Nedlands, Western Australia—
Earth Mite and Lucerne Flea Investigations—
Senior Research Officer—M. M. H. Wallace, B.Sc.

At Sydney—
Biological Control—
Senior Research Officer—G. J. Snowball, B.Sc.
Experimental Officer—R. G. Lukins, B.Sc. (in Hawaii).

Fruit Fly Ecology (with University of Sydney)—
Research Officer—M. A. Bateman, B.Sc.

14. DIVISION OF FISHERIES AND OCEANOGRAPHY.

(Head-quarters: Cronulla, New South Wales.)

At Cronulla—
Chief—G. F. Humphrey, M.Sc., Ph.D.
Technical Secretary—Mrs. L. M. Willings, B.A. (Hons.).
Librarian—Miss A. M. Copeland, B.A.(Hons.).
Research Fellow—L. G. M. Baas Becking, Ph.D., D.Sc. (with Bureau of Mineral Resources, Canberra).
Principal Research Officer—B. V. Hamon, D.Sc. (Hons.), B.E.(Hons.) (overseas).
Principal Research Officer—I. S. R. Munro, M.Sc.
Principal Research Officer—D. J. Rochford, B.Sc. (Hons.).
Principal Research Officer—J. M. Thomson, D.Sc.
Principal Research Officer—E. J. F. Wood, B.A., M.Sc.
Research Officer—R. G. Chittleborough, M.Sc., Ph.D.
Research Officer—D. E. Kurth, B.Sc.(Hons.).
Research Officer—R. J. MacIntyre, M.Sc. (overseas).
Research Officer—W. B. Malcolm, B.Sc., Ph.D. (overseas).
Research Officer—J. P. Robins, B.Sc.
Research Officer—H. B. Wisely, M.Sc. (overseas).
Experimental Officer—J. J. S. Bohanna, B.Sc.Ag.
Experimental Officer—N. L. Brown, A.S.T.C.
Experimental Officer—A. D. Crooks, B.Sc.
Experimental Officer—H. R. Jitts, B.Sc.
Experimental Officer—D. J. Tranter, B.Sc.

At Melbourne—
Research Officer—T. R. Cowper, B.Sc.(Hons.).

At Perth—
Senior Research Officer—K. Sheard, D.Sc.

At Hobart—
Principal Research Officer—A. G. Nicholls, B.Sc. (Hons.), Ph.D.
Senior Research Officer—A. M. Olsen, M.Sc.

At Thursday Island, Queensland—
Senior Research Officer—J. S. Hynd, B.Sc.(Hons.).

15. FODDER CONSERVATION SECTION.

(Head-quarters: Graham-road, Highett, Victoria.)

Officer-in-charge—W. L. Greenhill, M.E.
Senior Research Officer—G. W. Lanigan, M.Sc.
Senior Research Officer—Miss J. F. Couchman, M.Sc.
Research Officer—W. Shepherd, B.Sc., B.Agr.Sc.
Experimental Officer—J. E. de Freitas, F.R.M.T.C.
Experimental Officer—C. J. Brady, M.Sc.Agr.

16. DIVISION OF FOOD PRESERVATION AND TRANSPORT.

(Head-quarters: State Abattoir, Homebush Bay, New South Wales.)

At Homebush, New South Wales—
Administration—
Chief—J. R. Vickery, M.Sc., Ph.D. (overseas).
Technical Secretary—R. B. Withers, M.Sc., Dip.Ed.
Scientific Librarian—Miss B. E. Johnston, B.Sc.
Experimental Officer—Miss E. M. Christie, B.Sc.

Physics and Transport Section—
Senior Principal Research Officer—E. W. Hicks, B.A., B.Sc.
Senior Research Officer—M. C. Taylor, M.Sc.
Research Officer—H. L. Evans, M.Sc. (overseas).
Experimental Officer—N. D. Cowell, B.Sc.(Hons.).
Experimental Officer—J. D. Mellor.

Microbiology Section—
Senior Principal Research Officer—W. J. Scott, B.Agr. Sc., D.Sc. (overseas).
Senior Research Officer—W. G. Murrell, B.Sc.Agr., D.Phil.
Research Officer—J. H. B. Christian, B.Sc.Agr. (Hons.), Ph.D.
Research Officer—R. H. Leach, M.Sc., D.Phil.
Experimental Officer—D. F. Ohye, D.I.C.
Experimental Officer—Miss B. J. Marshall, A.S.T.C.
Experimental Officer—Miss K. M. Smith, B.Sc.

Biochemistry Investigations—
Principal Research Officer—F. E. Huelin, B.Sc. (Hons.), Ph.D.
Research Officer—J. B. Davenport, M.Sc.
Experimental Officer—B. H. Kennett, A.S.T.C.

Organic Chemistry Investigations—
Principal Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil.
Senior Research Officer—E. F. L. J. Anet, M.Sc., Ph.D.
Research Officer—D. L. Ingles, M.Sc., Ph.D.

Fruit and Vegetable Storage Section—
Principal Research Officer—E. G. Hall, B.Sc.Agr. (Hons.).
Research Officer—Miss J. M. Bain, M.Sc.
Research Officer—K. J. Scott, B.Sc.Agr., Dip.Ed. (at New South Wales Department of Agriculture).

Canning and Fruit Products Section—
Senior Principal Research Officer—L. J. Lynch, B.Agr.Sc.(Hons.) (overseas).
Principal Research Officer—J. F. Kefford, M.Sc.
Senior Research Officer—R. S. Mitchell, M.Sc.Agr.
Senior Research Officer—B. V. Chandler, B.Sc. (Hons.) (overseas).
Research Officer—E. G. Davis, B.Sc.(Hons.) (overseas).
Research Officer—P. W. Board, B.Sc.(Hons.).
Research Officer—D. J. Casimir, M.Sc., Dip.Ed.
Experimental Officer—K. A. Harper, B.Sc., A.S.T.C.

Dried Foods Section—
Senior Research Officer—D. McG. McBean, B.Sc.
Experimental Officer—A. A. Johnson, A.S.T.C.

Fish Preservation Investigations—
Principal Research Officer—W. A. Empey, B.V.Sc.
Experimental Officer—W. A. Montgomery, A.S.T.C.

Egg Investigations—
Chief—J. R. Vickery, M.Sc., Ph.D.
Experimental Officer—F. S. Shenstone, A.S.T.C.

Freezing of Fruit and Vegetables—
Senior Research Officer—J. Shipton, B.Sc.Agr.
Research Officer—J. H. Scheltema, M.Sc.
Experimental Officer—J. H. Last, A.S.T.C.

At Auburn, New South Wales—
Meat Dehydration Investigations—
Senior Research Officer—A. R. Prater, B.Sc.Agr.

At Botany School, University of Sydney—
Plant Physiology Investigations—
Chief Research Officer—R. N. Robertson, B.Sc., Ph.D., F.A.A.
Senior Research Officer—H. S. McKee, B.A., D.Phil. (on leave).
Senior Research Officer—J. F. Turner, M.Sc., Ph.D.
Senior Research Officer—Mrs. D. H. Turner, M.Sc., Ph.D.
Senior Research Officer—A. B. Hope, B.Sc., Ph.D.
Research Officer—M. D. Hatch, B.Sc.(Hons.).
Experimental Officer—N. F. B. Tobin, B.Sc.(Hons.).
Experimental Officer—J. Smydzuk, Ing. of Ch.
Experimental Officer—Miss J. E. King, B.Sc.

At Botany School, University of Melbourne—
Plant Physiology Investigations—
Senior Research Officer—K. S. Rowan, M.Sc., Ph.D.

At Biochemistry School, University of Sydney—
Physical Chemistry Section—
Senior Research Officer—H. A. McKenzie, M.Sc., Ph.D.
Research Officer—J. J. Macfarlane, M.Sc. (overseas).
Experimental Officer—M. B. Smith, A.S.A.S.M., B.Sc.
Experimental Officer—Miss J. F. Back, B.Sc., Dip.Ed.
Experimental Officer—Miss K. O. Kelly, B.Sc.

At Tasmanian Regional Laboratory, Hobart—
Processing of Fruit and Vegetables—
Experimental Officer—S. M. Sykes, B.Sc.Agr.
Experimental Officer—R. A. Gallop, A.S.T.C. (on leave).

At Cannon Hill, Queensland—
Meat Investigations—
Officer-in-charge—A. Howard, M.Sc.
Senior Research Officer—G. Kaess, Dr.Ing.
Research Officer—C. A. McChesney, B.Sc., Ph.D.
Experimental Officer—N. T. Russell, D.I.C.
Experimental Officer—M. F. Meaney, B.Sc.(Hons.).
Experimental Officer—P. E. Bouton, B.Sc.
Experimental Officer—J. F. Weidemann, B.Sc.
Experimental Officer—D. R. Davy, B.Sc.
Experimental Officer—C. A. Lee, B.Sc.

17. DIVISION OF FOREST PRODUCTS.

(Head-quarters: 69 Yarra Bank-road, South Melbourne, Victoria.)

Administration—
Chief—S. A. Clarke, B.E.
Assistant Chief—C. S. Elliot, B.Sc.
Assistant Chief—H. E. Dadswell, D.Sc.
Technical Secretary—F. A. Priest, A.S.A.S.M.
Information Officer—A. P. Wymond, M.Sc.
Scientific Librarian—Miss M. I. Hulme.
Librarian—Miss A. Forbes.
Senior Experimental Officer—L. Santer, M.Mech.E., Dip.Ing.
Drafting Officer—R. R. Henderson.

Wood and Fibre Structure Section—
Assistant Chief—H. E. Dadswell, D.Sc.
Senior Principal Research Officer—A. B. Wardrop, D.Sc., Ph.D.
Senior Research Officer—Miss M. M. Chattaway, M.A., B.Sc., D.Phil.
Senior Research Officer—W. E. Hillis, M.Sc., A.G.Inst.Tech.
Senior Research Officer—H. D. Ingle, B.For.Sc.
Research Officer—J. Cronshaw, B.Sc., Ph.D.
Experimental Officer—J. W. P. Nicholls, B.Sc.
Experimental Officer—Miss A. Carle, B.Sc., A.G.Inst.Tech.
Experimental Officer—G. W. Davies, B.Sc.

Wood Chemistry Section—
Senior Principal Research Officer—W. E. Cohen, D.Sc. (overseas).
Principal Research Officer—D. E. Bland, M.Sc.
Principal Research Officer—H. G. Higgins, B.Sc. (Hons.).
Senior Research Officer—R. C. McK. Stewart, B.Sc. (overseas).
Senior Research Officer—A. J. Watson, A.R.M.T.C.
Experimental Officer—A. W. McKenzie, A.R.M.T.C.
Experimental Officer—J. L. de Yong, B.Sc.
Experimental Officer — Miss V. Goldsmith, A.R.M.T.C.
Experimental Officer—Mrs. M. Szilagyi, Dip.Ind. Chem.
Experimental Officer—Mrs. G. E. Urbach, M.Sc.

Timber Physics Section—
Principal Research Officer—R. S. T. Kingston, B.Sc., B.E.
Senior Research Officer—G. N. Christensen, M.Sc., Ph.D.
Senior Research Officer—L. N. Clarke, M.Mech.E., B.Eng.Sc.
Research Officer—Miss K. E. Kelsey, M.Sc. (on leave).
Experimental Officer—L. D. Armstrong, A.R.M.T.C.
Experimental Officer—D. R. Callow, B.E.
Experimental Officer—N. C. Edwards, A.S.M.B.
Experimental Officer—P. U. A. Grossman, M.Sc., Ph.A.Mr. (on leave).
Experimental Officer—J. Rozulapa, Dip.Phys.

Timber Mechanics Section—
Principal Research Officer—J. D. Boyd, M.C.E.
Principal Research Officer—N. H. Kloot, M.Sc.
Principal Research Officer—R. G. Pearson, B.A., B.C.E.
Experimental Officer—R. N. Bournon.
Experimental Officer—J. J. Mack, A.R.M.T.C.
Experimental Officer—Miss A. Ryan, A.R.M.T.C.
Experimental Officer—K. B. Schuster, A.R.M.T.C.

Timber Preservation Section—
Senior Principal Research Officer—N. Tamblyn, M.Sc.(Agric.).
Senior Research Officer—E. W. B. DaCosta, M.Agr.Sc.
Senior Research Officer—E. L. Ellwood, B.Sc.For., M.Sc., Ph.D. (on leave).
Senior Research Officer—R. Johanson, M.Sc.
Research Officer—P. Rudman, B.Sc., Ph.D., Dip. Microbiol.
Senior Experimental Officer—F. A. Dale, Dip. Mech.E.
Experimental Officer—J. Beesley, Dip.For., M.Sc. (For.).
Experimental Officer—N. E. M. Walters, B.Sc.
Experimental Officer—Miss F. J. Lloyd, B.Sc. (on leave).
Experimental Officer—D. F. McCarthy, A.R.M.T.C.
Experimental Officer—J. F. Barnacle, Dip.Mech.E., Dip.E.E.

Timber Seasoning Section—
Senior Principal Research Officer—G. W. Wright, M.E.
Research Officer—W. G. Kauman, B.Sc., A.R.M.T.C. (on leave).
Experimental Officer—L. J. Brennan.
Experimental Officer—G. S. Campbell.
Experimental Officer—F. J. Christensen, A.R.M.T.C.
Experimental Officer—R. H. Capes, B.E.
Experimental Officer—W. R. Finighan, A.R.M.T.C.
Experimental Officer—K. W. Fricke, Assoc.Aero.Eng.
Experimental Officer—R. M. Liversidge, A.R.M.T.C.

Plywood Investigations Section—
Principal Research Officer—J. W. Gottstein, B.Sc.
Experimental Officer—K. Hirst, Dip.Mech.Eng.
Experimental Officer—P. J. Moglia, Dip.Mech.E.
Experimental Officer—A. Stashevski, Dip.For.Eng., E.T.H.

Timber Utilization Section—
Senior Principal Research Officer—R. F. Turnbull, B.E.
Senior Research Officer—K. F. Plomley, B.Sc. (Agric.).
Research Officer—W. M. McKenzie, M.Sc.(For.).
Experimental Officer—R. L. Cowling, Dip.Mech.E., Dip.E.E.
Experimental Officer—D. S. Jones, B.C.E.
Experimental Officer—M. W. Page.
Experimental Officer—R. K. Profitt, Dip.App.Sc.

18. DIVISION OF INDUSTRIAL CHEMISTRY.

(Head-quarters: Lorimer-street, Fishermen's Bend, Victoria.)

Administration—
Chief—I. W. Wark, D.Sc., Ph.D., F.A.A.
Divisional Secretary—W. E. Ewers, M.Sc.
Assistant Secretary—R. J. Davidson, B.Sc.

Minerals Utilization Section—
Chief Research Officer—R. G. Thomas, B.Sc.
Senior Principal Research Officer—A. Walkley, M.A., D.Sc., Ph.D.
Principal Research Officer—R. C. Croft, M.Sc.
Principal Research Officer—F. K. McTaggart, M.Sc.
Principal Research Officer—I. E. Newnham, M.Sc.
Principal Research Officer—T. R. Scott, D.Sc., B.Ed.
Principal Research Officer—A. D. Wadsley, D.Sc.
Principal Research Officer—A. W. Wylie, D.Sc., Ph.D.
Senior Research Officer—E. S. Pilkington, A.S.T.C.
Senior Research Officer—I. H. Warren, B.Sc.(Hons.), Dipl.Chem.Techn. (on leave).
Research Officer—K. J. Cathro, B.E., Ph.D.
Research Officer—H. J. Gardner, B.Sc., Ph.D.
Research Officer—D. F. A. Koch, B.Sc.(Hons.), Ph.D.
Research Officer—D. E. Scaife, B.Sc.(Hons.) (on leave).
Research Officer—A. G. Turnbull, B.Chem.Eng. (Hons.), M.Eng.Sc. (on leave).
Experimental Officer—H. R. Skewes, A.A.C.I.
Experimental Officer—Miss I. J. Bear, A.R.M.T.C.
Experimental Officer—B. M. Beattie, B.Sc.
Experimental Officer—Miss E. E. Rutherford, B.Sc.
Experimental Officer—B. C. Molony, A.R.M.T.C.
Experimental Officer—L. J. Rogers, A.R.M.T.C.
Experimental Officer—P. R. Smith, A.R.M.T.C.

Cement and Ceramics Section—
Senior Principal Research Officer—A. J. Gaskin, M.Sc.
Principal Research Officer—H. E. Vivian, B.Sc.Agr.
Principal Research Officer—G. F. Walker, B.Sc., Ph.D.
Principal Research Officer—W. O. Williamson, D.Sc., Ph.D.
Senior Research Officer—K. M. Alexander, M.Sc., Ph.D.
Senior Research Officer—S. M. Brisbane, B.A., B.Sc., A.R.M.T.C.
Senior Research Officer—H. Ellerton, F.Inst.Ceram. (at Bonython Research Laboratory, School of Mines, Adelaide).
Senior Research Officer—L. S. Williams, D.Phil., B.E.
Research Officer—G. M. Bruère, M.Sc.
Research Officer—J. Graham, M.Sc., Ph.D.
Research Officer—J. H. Taplin, B.Sc.(Hons.).
Experimental Officer—K. Grant, B.Sc.(Hons.).
Experimental Officer—J. H. Weymouth, B.Sc.
Experimental Officer—C. E. S. Davis, B.Sc.(Hons.).
Experimental Officer—F. C. Gillespie, B.Sc.
Experimental Officer—R. R. Hughan.
Experimental Officer—J. Wardlaw, B.Sc.(Hons.).
Experimental Officer—J. D. Wolfe.
Experimental Officer—A. Adami, B.Chem.Eng.
Experimental Officer—Miss V. Anderlini, B.Sc.
Experimental Officer—P. J. Darragh, B.Sc.(Hons.).
Experimental Officer—W. G. Garrett, A.R.M.T.C.
Experimental Officer—Miss B. C. Terrell, B.Sc.

Foundry Sands Section—
Senior Research Officer—H. A. Stephens, B.Sc.
Experimental Officer—A. N. Waterworth, A.H.T.C.
Experimental Officer—P. W. Goad, F.R.M.T.C.

Chemical Physics Section—
Assistant Chief of Division—A. L. G. Rees, D.Sc., Ph.D., F.A.A.
Senior Principal Research Officer—A. Walsh, M.Sc. Tech., F.A.A.
Senior Principal Research Officer—J. M. Cowley, D.Sc., Ph.D.
Principal Research Officer—J. L. Farrant, M.Sc.
Principal Research Officer—A. McL. Mathieson, D.Sc., Ph.D.
Principal Research Officer—J. J. McNeill, M.Sc.
Principal Research Officer—D. A. Davies, B.Sc. (Hons.).
Principal Research Officer—J. D. Morrison, B.Sc., Ph.D.
Principal Research Officer—J. B. Willis, M.Sc., Ph.D.
Principal Research Officer—A. F. Moodie, B.Sc. (Hons.).
Principal Research Officer—A. C. Hurley, M.A., B.Sc., Ph.D.
Senior Research Officer—A. J. C. Nicholson, M.Sc., Ph.D.
Senior Research Officer—J. Fridrichsons, M.Sc.
Senior Research Officer—G. R. Hercus, M.Sc., D.Phil.
Senior Research Officer—B. Dawson, M.Sc., Ph.D.
Senior Research Officer—C. K. Coogan, M.Sc., Ph.D.
Senior Research Officer—F. H. Dorman, M.A., M.Sc., Ph.D.
Senior Research Officer—A. F. Beecham, B.Sc. (Hons.).
Research Officer—C. Billington, B.A.
Research Officer—J. O. Cope, M.Sc., Ph.D.
Research Officer—J. D. McLean, B.Sc.(Hons.), Ph.D.
Research Officer—N. S. Ham, M.Sc., Ph.D.
Research Officer—J. V. Sullivan, M.Sc. (at University of Western Australia, Perth).
Research Officer—P. Goodman, M.Sc.
Research Officer—W. C. T. Dowell, M.Sc.
Research Officer—E. G. McRae, M.Sc., Ph.D.
Experimental Officer—S. E. Powell.
Experimental Officer—G. F. H. Box.

Experimental Officer—E. Chakanovskis, Dipl.Eng.
Experimental Officer—D. L. Swingler, B.Sc.
Experimental Officer—Miss M. Calame, B.Sc.

Physical Chemistry Section—

Assistant Chief of Division—K. L. Sutherland, D.Sc., Ph.D.
Senior Principal Research Officer—S. D. Hamann, M.Sc., Ph.D. (at Department of Chemical Engineering, University of Sydney).
Principal Research Officer—J. A. Barker, B.A. (Hons.), D.Sc.
Principal Research Officer—I. Brown, B.Sc.(Hons.).
Principal Research Officer—V. A. Garten, D.Sc.
Principal Research Officer—W. W. Mansfield, B.Sc. (Hons.).
Principal Research Officer—D. E. Weiss, B.Sc.
Principal Research Officer—M. E. Winfield, D.Sc., Ph.D.
Senior Research Officer—H. G. David, B.Sc. (Hons.) (at Department of Chemical Engineering, University of Sydney).
Senior Research Officer—A. Ewald, B.Sc., Ph.D. (at Department of Chemical Engineering, University of Sydney).
Senior Research Officer—W. N. K. King, B.Sc.
Senior Research Officer—E. A. Swinton, B.Sc. (Hons.).
Senior Research Officer—R. G. Vines, M.Sc., B.Sc.
Research Officer—R. B. Head, M.Sc., Ph.D.
Research Officer—A. R. King, B.Sc., Ph.D.
Research Officer—F. H. C. Stewart, Ph.D.
Experimental Officer—L. F. Evans, D.S.M.B.
Experimental Officer—K. Eppinger, B.Sc.
Experimental Officer—W. Fock, B.Sc.
Experimental Officer—M. Linton, B.Sc.
Experimental Officer—R. McNeill, A.S.T.C.
Experimental Officer—F. Smith, B.Sc.
Experimental Officer—Mrs. J. H. Wardlaw, B.Sc.

Organic Chemistry Section—

Senior Principal Research Officer—H. H. Hatt, D.Sc., Ph.D.
Senior Principal Research Officer—J. R. Price, D.Sc., D.Phil.
Principal Research Officer—K. E. Murray, B.Sc. (Hons.).
Principal Research Officer—K. W. Zimmerman, D.Ing.
Senior Research Officer—C. S. Barnes, M.Sc., Ph.D.
Senior Research Officer—R. B. Bradbury, B.Sc., Ph.D. (at University of Adelaide, South Australia).
Senior Research Officer—W. D. Crow, M.Sc., Ph.D.
Senior Research Officer—C. C. J. Culvenor, Ph.D., D.Phil.
Senior Research Officer—L. K. Dalton, A.S.T.C.
Senior Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Senior Research Officer—J. A. Lamberton, B.Sc., Ph.D.
Research Officer—J. R. Cannon, M.Sc., Ph.D.
Research Officer—D. T. Downing, B.Sc.(Hons.), Ph.D.
Research Officer—E. Gellert, Ph.D.
Research Officer—C. Kowala, B.Sc.(Hons.).
Research Officer—B. P. Moore, B.Sc., Ph.D., D.Phil.
Research Officer—P. C. Wailes, M.Sc., Ph.D.
Experimental Officer—P. M. Hunter, A.R.M.T.C..
Experimental Officer—Z. Kranz, Ind.Chem.
Experimental Officer—A. H. Redcliffe, Dip.Anal. Chem.
Experimental Officer—L. W. Smith, B.Sc.
Experimental Officer—A. C. K. Triffett, A.R.M.T.C.
Experimental Officer—Miss N. H. Corbett, B.Sc.
Experimental Officer—Mrs. F. O. Doy, B.Sc. (Hons.).
Experimental Officer—Mrs. I. Salivin, A.R.M.T.C.

Chemical Engineering Section—

Chief Research Officer—H. R. C. Pratt, D.Sc., Ph.D.
Principal Research Officer—J. D. Blackwood, M.Sc., Ph.D.
Principal Research Officer—R. W. Urie, B.Sc., S.M.
Senior Research Officer—T. J. Birch, Chem.Eng., B.Sc.
Senior Research Officer—O. G. Ingles, B.A., M.Sc.
Senior Research Officer—A. B. Whitehead, B.Sc. (Hons.).
Research Officer—K. R. Hall, M.Sc.
Experimental Officer—B. W. Wilson, M.Sc.
Experimental Officer—P. Casamento, D.Chem.
Experimental Officer—A. J. Stedman, M.A.
Experimental Officer—A. J. Ingeme, A.R.M.T.C.
Experimental Officer—C. J. Restarick, A.S.M.B.
Experimental Officer—R. L. Simpson, B.Chem.Eng.

Engineering Services—

Experimental Officer—J. B. Ross, B.Sc., A.R.M.T.C.
Senior Drafting Officer—C. Simpson.

Library—

Scientific Librarian—Miss B. M. Brown, B.Sc.

19. INDUSTRIAL RESEARCH LIAISON SECTION.

(Head-quarters: 314 Albert-street, East Melbourne, Victoria.)

Officer-in-charge—L. Lewis, B.Met.E.
Senior Research Officer—J. P. Shelton, M.Sc., A.B.S.M.
Senior Research Officer—J. F. H. Wright, B.Sc.
Experimental Officer—J. D. Dover, A.S.T.C.

20. IRRIGATION RESEARCH STATIONS.

(Head-quarters: Merbein, Victoria.)

Senior Officer-in-charge—F. Penman, M.Sc.

At Commonwealth Research Station, Merbein (Murray Irrigation Areas)—

Officer-in-charge—F. Penman, M.Sc.
Technical Secretary—D. V. Walters, M.Agr.Sc.
Principal Research Officer—J. G. Baldwin, B.Agr.Sc., B.Sc.
Research Officer—W. J. Webster, B.Sc.
Research Officer—A. J. Antcliff, B.Sc.(Hons.).
Research Officer—M. R. Sauer, B.Agr.Sc.
Research Officer—S. F. Bridley, B.Agr.Sc.
Research Officer—R. C. Woodham, B.Agr.Sc.
Research Officer—D. McE. Alexander, B.Sc.
Research Officer—A. F. Bird, M.Sc., Ph.D.
Research Officer—J. V. Seekamp, B.Agr.Sc. (part-time).
Experimental Officer—S. A. Giddings, B.Sc. (on leave).
Experimental Officer—P. May, Ing.Agr.
Experimental Officer—D. G. M. Blair, B.Agr.Sc.

At Irrigation Research Station, Griffith (Murrumbidgee Irrigation Areas)—

Officer-in-charge—E. R. Hoare, B.Sc.
Senior Research Officer—C. T. Gates, M.Sc.Agr.
Research Officer—R. F. Black, B.Sc.(Hons.), Ph.D.
Research Officer—T. Talsma, Ir.Agr.
Research Officer—D. Bouma, Ir.Agr.
Research Officer—H. Groenewegen, Ir.Agr.
Librarian—Miss M. Russell (on leave).
Librarian—Miss T. Schmitz, Ph.D.

21. DIVISION OF LAND RESEARCH AND REGIONAL SURVEY.

(Head-quarters: Canberra, Australian Capital Territory.)

Head-quarters—

Chief—C. S. Christian, B.Agr.Sc., M.S.
Technical Secretary—Miss M. Mills, B.Sc.(Hons.).
Research Officer—J. J. Basinski, B.Sc., M.A.

Regional Surveys—
Principal Research Officer—G. A. Stewart, M.Agr.Sc.

Australian Mainland Survey, Canberra—
Senior Research Officer—R. A. Perry, M.Sc.
Senior Research Officer.—N. H. Speck, M.Sc., B.A.
Research Officer—W. H. Litchfield, B.Sc.Agr. (seconded from Division of Soils).
Experimental Officer—M. Lazarides, Q.D.A.

Papua-New Guinea Survey, Canberra—
Senior Research Officer—H. A. Haantjens, Ing.Agr.
Senior Research Officer—R. D. Hoogland, D.Sc.
Research Officer—R. G. Robbins, M.Sc., Ph.D.
Research Officer—E. J. Reiner, Dr.rer.nat.
Experimental Officer—C. J. Saunders, B.Sc.Agr.

Agricultural Research—
Principal Research Officer—E. Phillis, Ph.D., D.Sc.

At Katherine Research Station, Northern Territory—
Senior Research Officer—W. Arndt, B.Agr.Sc.
Research Officer—M. J. T. Norman, B.Sc.(Hons.), Ph.D.
Research Officer—R. Wetselaar, Ing.Agr.
Experimental Officer—W. R. Stern, M.Sc.Agr. (on leave).

At Kimberley Research Station, Western Australia—
Experimental Officer—A. L. Chapman, B.Agr.Sc.
Experimental Officer—E. C. B. Langfield.
Experimental Officer—N. J. P. Thomson, B.Agr.Sc.

Climatology, Alice Springs—
Senior Research Officer—R. O. Slatyer, M.Sc. (Agric.).
Research Officer—J. L. Frith, B.Sc.(Agr.)(Hons.).
Research Officer—J. C. Turner, B.Sc.Agr.(Hons.).

Geomorphology, Canberra—
Senior Research Officer—J. A. Mabbutt, M.A. (Hons.).
Research Officer—R. L. Wright, M.Sc.

Hydrology, Canberra—
Research Officer—T. G. Chapman, B.Sc.(Hons.), Ph. D.

Arid Zone Research—
Senior Research Officer—R. A. Perry, M.Sc.

At Alice Springs—
Experimental Officer—R. E. Winkworth, B.Sc. (Hons.).

22. MATHEMATICAL INSTRUMENTS SECTION.

(Head-quarters: Department of Electrical Engineering, University of Sydney.)

Officer-in-charge—Professor D. M. Myers, B.Sc., D.Sc. Eng.
Research Officer—M. W. Allen, B.E. (Hons.).

23. DIVISION OF MATHEMATICAL STATISTICS.

(Head-quarters: University of Adelaide.)

At Head-quarters, Adelaide—
Chief—E. A. Cornish, B.Agr.Sc., D.Sc., F.A.A.
Principal Research Officer—A. T. James, M.Sc., Ph.D.
Research Officer—G. N. Wilkinson, M.Sc.
Research Officer—A. G. Constantine, B.Sc.(Hons.).
Experimental Officer—Miss M. J. Evans, B.A.
Experimental Officer—K. M. Cellier, B.Sc.
Experimental Officer—L. G. Veitch, B.Sc.

At Division of Animal Health and Production, Prospect, New South Wales—
Research Officer—H. Weiler, Lic.ès.Sc., M.Sc.

At Division of Animal Health and Production, Sydney—
Experimental Officer—A. D. Phillips, M.B., B.S.

At Division of Building Research, Highett, Victoria—
Senior Research Officer—R. Birtwistle, B.Sc.
Experimental Officer—C. E. Billigheimer, B.A. (Hons.), B.Sc.

At Division of Food Preservation and Transport, Homebush, New South Wales—
Senior Research Officer—G. G. Coote, B.A., B.Sc.
Experimental Officer—E. A. Roberts, B.Sc.Agr.

At Division of Forest Products, Melbourne—
Research Officer—W. R. Flower, B.Sc., B.A.(Hons.).
Experimental Officer—Miss N. Ditchbourne.

At Division of Plant Industry, Brisbane—
Research Officer—K. P. Haydock, B.Sc.(Hons.).

At Division of Plant Industry, Canberra—
Senior Principal Research Officer—G. A. McIntyre, B.Sc.(Hons.), Dip.Ed.
Research Officer—M. L. Dudzinski, B.Sc., B.Ec. (Hons.).

At Regional Pastoral Laboratory, Armidale, New South Wales—
Research Officer—P. F. May, B.Sc.Agr.(Hons.).

At University of Melbourne, School of Agriculture—
Research Officer—A. M. W. Verhagen, Cand.Nat. Phil., B.A.(Hons.).

At University of Melbourne—
Research Officer—G. W. Hill, M.Sc.

At Western Australian Regional Laboratory, Perth—
Senior Research Officer—N. S. Stenhouse, B.Sc.
Experimental Officer—C. A. P. Boundy, B.E.

At Wool Textile Research Laboratories, Melbourne—
Research Officer—W. B. Hall, B.A.

24. DIVISION OF METEOROLOGICAL PHYSICS.

(Head-quarters: Station-street, Aspendale, Victoria.)

Chief—C. H. B. Priestley, M.A., Sc.D., F.A.A.
Senior Principal Research Officer—W. C. Swinbank, M.Sc.
Senior Principal Research Officer—E. L. Deacon, B.Sc.
Principal Research Officer—A. F. A. Berson, Dr.Phil.
Senior Research Officer—R. J. Taylor, B.Sc.
Senior Research Officer—I. C. McIlroy, B.Sc.
Senior Research Officer—E. K. Webb, B.A.(Hons.), B.Sc.
Senior Research Officer—R. H. Clarke, B.A., B.Sc.
Research Officer—A. J. Dyer, M.Sc., Ph.D.
Research Officer—F. K. Ball, B.Sc.(Hons.).
Research Officer—C. F. Barrett, M.Sc.
Research Officer—P. J. Funk, Dr.Phil.
Experimental Officer—D. E. Angus, B.Sc.
Experimental Officer—R. R. McGregor, Dip.App.Sc.
Experimental Officer—A. J. Troup, B.Sc.
Experimental Officer—C. J. Sumner, A.M.S.E.
Experimental Officer—F. J. Maher, A.R.M.T.C.
Experimental Officer—B. G. Collins, B.Sc.
Experimental Officer—N. E. Bacon, B.Sc.
Experimental Officer—Miss S. A. Yeo, B.Sc.
Librarian—I. S. Groodin.

25. DIVISION OF METROLOGY.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Administration—
Chief—N. A. Esserman, B.Sc.
Technical Secretary—J. Hanna.
Experimental Officer—I. A. Rey, A.M.I.E., I.E.E. (Elec.).
Drafting Officer—J. R. B. Weir.

Length Section—

Principal Research Officer—M. J. Puttock, B.Sc. (Eng.).
Senior Research Officer—N. J. C. Peres, M.Sc.
Research Officer—Miss M. G. I. Pearce, M.Sc.
Research Officer—E. G. Thwaite, B.Sc.
Research Officer—P. J. Sim, B.E., B.Sc.
Experimental Officer—R. H. Furniss, A.S.T.C.
Experimental Officer—B. H. P. Cresswell, A.S.T.C.
Experimental Officer—Miss M. C. Dive, B.Sc.
Experimental Officer—J. W. Bell.
Experimental Officer—Miss P. M. Yelland.

Mass Section—

Principal Research Officer—G. A. Bell, B.Sc.
Research Officer—I. F. Mayer, B.E., B.Sc.
Experimental Officer—J. W. Humphries, B.Sc.
Experimental Officer—E. Grunwald, Dip.Ing.

Interferometry Section—

Principal Research Officer—C. F. Bruce, M.Sc.
Senior Research Officer—H. J. Ritter, Dr.rer.nat. math.
Research Officer—P. E. Ciddor, M.Sc.
Experimental Officer—R. S. Fisher, A.R.M.T.C.
Experimental Officer—S. T. Willatt, B.Sc.

Electronics Section—

Senior Research Officer—H. A. M. Ross, A.S.T.C.
Experimental Officer—J. L. Goldberg, B.E., B.Sc.

Applied Mechanics Section—

Senior Principal Research Officer—C. A. Gladman, B.Sc.(Eng.).
Principal Research Officer—J. A. Macinante, B.E., A.S.T.C.
Senior Research Officer—G. Lorenz, Dipl.Ing.Eth.
Research Officer—R. F. Scrutton, M.Sc.
Experimental Officer—R. Springer, Dr.Mach.Const.
Experimental Officer—R. J. Ellis, B.E.
Experimental Officer—J. Waldersee, B.Sc.
Experimental Officer—D. H. Fox.
Experimental Officer—A. A. V. Gibson, A.S.T.C.
Experimental Officer—L. Cridland, B.E., A.S.T.C.
Experimental Officer—K. Edensor, A.S.T.C.

26. MINERAGRAPHIC INVESTIGATIONS.

(Head-quarters: University of Melbourne.)

Officer-in-charge—A. B. Edwards, D.Sc., Ph.D., D.I.C.
Principal Research Officer—G. Baker, D.Sc.
Senior Research Officer—J. McAndrew, M.Sc., Ph.D.
Research Officer—I. M. Threadgold, B.Sc.
Research Officer—K. L. Williams, B.Sc.
Experimental Officer—A. W. Hounslow, F.R.M.T.C.

27. NATIONAL STANDARDS LABORATORY.

(The services shown hereunder are common to the Divisions of Metrology, Electrotechnology, and Physics, housed in the Laboratory at the University of Sydney.)

Clerical—

Chief Clerk—F. J. Whitty, A.A.S.A., A.C.I.S., J.P.
Accountant—T. C. Clark, A.A.S.A.

Library—

Scientific Librarian—Miss M. McKechnie, B.A.
Scientific Librarian—Miss P. M. Callaghan, B.Sc.
Scientific Librarian—Miss R. E. Moulden, B.Sc., Dip.Ed.
Senior Librarian—Miss J. M. Cooke, B.A.(Hons.).

28. ORE-DRESSING INVESTIGATIONS.

(Head-quarters: University of Melbourne.)

Officer-in-charge—Associate Professor H. H. Dunkin, B.Met.E.
Principal Research Officer—K. S. Blaskett, B.E.
Senior Research Officer—S. B. Hudson, M.Sc.
Senior Research Officer—J. T. Woodcock, B.Met.E., M.Eng.Sc.
Experimental Officer—F. D. Drews.
Experimental Officer—W. J. Trahar, B.Sc.
Experimental Officer—J. S. Henkel, B.Met.E.
Experimental Officer—K. H. G. Voss.
Experimental Officer—Miss J. Richardson, B.Sc.
Experimental Officer—Miss K. G. White, B.Met.E.

29. PHYSICAL METALLURGY SECTION.

(Head-quarters: University of Melbourne.)

Officer-in-charge—Professor H. W. Worner, D.Sc.
Principal Research Officer—R. C. Gifkins, B.Sc.
Research Officer—D. R. Miller, M.Sc., Ph.D.
Research Officer—J. W. Suiter, M.Sc., Ph.D. (on leave).
Experimental Officer—J. A. Corbett, A.M.A.I.M.M.
Experimental Officer—H. F. Ryan, B.Sc.

30. DIVISION OF PHYSICS.

(Head-quarters: National Standards Laboratory at the University of Sydney.)

Administration—

Chief—Dr. G. H. Briggs, D.Sc., Ph.D.
Laboratory Secretary—A. G. Driver, B.Sc.
Senior Drafting Officer—R. A. Partridge.

Heat—

Senior Principal Research Officer—A. F. A. Harper, M.Sc.
Principal Research Officer—R. G. Wylie, M.Sc., Ph.D.
Principal Research Officer—P. G. Klemens, M.Sc., D.Phil.
Senior Research Officer—W. R. G. Kemp, B.Sc.
Senior Research Officer—G. S. Bogle, M.A., D.Phil., M.Sc.
Research Officer—W. A. Caw, B.Sc.
Research Officer—J. Middlehurst, M.Sc.
Research Officer—J. V. McAllan, B.Sc.
Experimental Officer—Miss I. M. Beavis, B.Sc., Dip.Ed.
Experimental Officer—T. P. Jones, B.Sc.
Experimental Officer—N. R. Hickson, B.Sc.
Experimental Officer—C. W. G. Thomas, B.Sc.
Experimental Officer—L. Kaagjarv, M.Sc.
Experimental Officer—R. W. Tainsh, A.S.T.C.

Light—

Senior Principal Research Officer—R. G. Giovanelli, D.Sc.
Principal Research Officer—W. H. Steel, B.A., Dr.ès.Sc.
Senior Research Officer—J. V. Ramsay, B.Sc., Ph.D., D.I.C.
Research Officer—W. R. Blevin, M.Sc., Dip.Ed.
Experimental Officer—K. A. B. Wright, B.Sc.
Experimental Officer—W. J. Brown, A.S.T.C.
Experimental Officer—Miss M. C. Cunningham, B.Sc.

Solar Physics—

Research Officer—J. T. Jefferies, M.A., B.Sc. (overseas).
Research Officer—R. E. Loughhead, M.Sc.
Research Officer—R. J. Bray, M.A., D.Phil.
Experimental Officer—Miss M. K. McCabe, M.Sc.
Experimental Officer—V. R. Burgess, A.S.T.C.

Electronics—

Research Officer—A. F. Young, M.Sc.

31. Division of Plant Industry.

(Head-quarters: Canberra, Australian Capital Territory.)

Administration—

Chief—O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S. (overseas).
Associate Chief—J. Griffiths Davies, B.Sc., Ph.D.
Assistant Chief—R. M. Moore, M.Sc.Agr.
Technical Secretary—A. Shavitsky, B.Agr. Sc. (overseas with A.S.L.O., London).
Acting Technical Secretary—J. H. E. Mackay, B.Sc.Agr.
Assistant Technical Secretary—L. G. Wilson, M.Sc.
Division Engineer—G. L. Brown, B.Sc.(Eng.).

At Canberra, Australian Capital Territory—

Genetics, Cytology, and Structural Botany—

Chief of the Division—O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S. (overseas).
Principal Research Officer—C. Barnard, D.Sc.
Senior Research Fellow—J. B. Griffing, M.S., Ph.D.
Principal Research Officer—F. H. W. Morley, B.V.Sc., Ph.D. (overseas).
Senior Research Officer—R. D. Brock, M.Agr.Sc., Ph.D.
Senior Research Officer—J. B. Langridge, M.Sc., Ph.D.
Senior Research Officer—D. C. Wark, M.Agr.Sc.
Research Officer—H. Daday, M.Sc.
Research Officer—C. I. Davern, M.Sc.Agr. (overseas).
Research Officer—D. L. Hayman, B.Ag.Sc.(Hons.), Ph.D.
Research Officer—D. M. Moore, B.Sc.(Hons.), Ph.D.
Research Officer—J. R. McWilliam, B.Sc.(Hons.), M.F.
Experimental Officer—Miss A. M. Munday, B.Sc.

Herbarium—

Senior Research Officer—Miss N. T. Burbidge, M.Sc.

Plant Introduction—

Senior Principal Research Officer—W. Hartley, B.A., Dip.Ag.
Senior Research Officer—C. A. Neal-Smith, B.Ag.Sc.
Experimental Officer—Miss D. E. Johns, B.Sc.
Experimental Officer—Miss C. R. Warner, B.Sc.Agr.
Experimental Officer—R. J. Williams, M.Sc.

Microbiology—

Senior Research Officer—F. W. Hely, M.Sc.Agr., M.S.
Research Officer—F. J. Bergersen, M.Sc.(Hons.).
Research Officer—I. A. M. Cruickshank, M.Sc. (Hons.)
Research Officer—A. H. Gibson, B.Sc.Agr.(Hons.) (overseas).
Research Officer—Miss K. Helms, M.Sc., Ph.D.
Experimental Officer—J. Brockwell, D.D.A.
Experimental Officer—Miss B. Ballantyne, B.Sc.Agr.
Experimental Officer—Mrs. D. R. Perrin, M.Sc.

Disease Control—

Principal Research Officer—H. R. Angell, O.B.E., B.Sc.Agr., M.S., Ph.D.

Tobacco Investigations—

Principal Research Officer—A. V. Hill, M.Agr.Sc.
Experimental Officer—M. Mandryk, B.Sc.Agr.

General Chemistry—

Principal Research Officer—C. H. Williams, M.Sc.
Senior Research Officer—D. J. Cosgrove, B.Sc. (Hons.), Ph.D.
Senior Research Officer—A. Steinbergs, Dip.Chem. Eng.
Research Officer—D. J. David, M.Sc.
Experimental Officer—J. R. Twine, Dip.Ind.Chem.

Plant Nutrition—

Senior Principal Research Officer—A. J. Anderson, D.Sc.(Agric.).
Senior Research Officer—K. D. McLachlan, B.Sc.Agr., B.Com. (overseas).
Senior Research Officer—D. Spencer, B.Sc.(Hons.), Ph.D.
Research Officer—J. F. Loneragan, B.Sc.(Hons.), Ph.D.
Research Officer—J. V. Possingham, B.Ag.(Hons.), Ph.D.

Plant Biochemistry and Biophysics—

Senior Principal Research Officer—J. E. Falk, M.Sc., Ph.D.
Principal Research Officer—C. G. Greenham, M.Sc.
Senior Research Officer—N. K. Boardman, M.Sc., Ph.D.
Senior Research Officer—W. Bottomley, B.Sc. (Hons.), Ph.D.
Senior Research Officer—P. L. Goldacre, M.Sc., Ph.D.
Senior Research Officer—J. N. Phillips, M.Sc., Ph.D.
Senior Research Officer—S. W. Thorne, B.Sc. (Hons.).
Research Officer—C. A. Appleby, B.Sc.(Hons.), Ph.D.
Research Officer—S. M. Bromfield, M.Agr.Sc., Ph.D.
Research Officer—P. A. Trudinger, B.Sc.(Hons.), Ph.D.
Research Officer—N. A. Walker, B.Sc.(Hons.).
Research Officer—P. R. Whitfield, B.Sc.(Hons.), Ph.D.
Experimental Officer—P. I. Mortimer, M.Sc. (on leave).
Experimental Officer—R. J. Porra, B.Sc.
Experimental Officer—Mrs. M. B. Lowe, B.Sc. (Hons.).

Plant Physiology—

Principal Research Officer—L. A. T. Ballard, M.A., M.Agr.Sc., Ph.D. (overseas).
Principal Research Officer—R. F. Williams, D.Sc.
Senior Research Officer—A. H. G. C. Rijven, B.Sc., Ph.D.
Senior Research Officer—L. T. Evans, B.Sc., M.Agr.Sc., D. Phil.
Research Officer—N. P. Kefford, M.Sc., Ph.D.
Research Officer—W. G. Slater, M.Sc., D.Phil.
Research Officer—J. A. Zwar, M.Ag.Sc. (overseas).
Experimental Officer—Miss A. E. Grant Lipp, M.Sc.
Experimental Officer—P. K. Macnicol, M.Sc.

Ecology—

Assistant Chief of the Division—R. M. Moore, M.Sc.Agr.
Senior Research Officer—E. F. Biddiscombe, M.Sc. (Agric.).
Senior Research Officer—R. W. Jessup, M.Sc.
Senior Research Officer—C. W. E. Moore, M.Agr.Sc.
Senior Research Officer—G. Scurfield, B.Sc., Dip.Ed., Ph.D.
Research Officer—J. A. Carnahan, M.Sc.(Hons.).
Research Officer—P. W. Michael, B.Agr.Sc.(Hons.).
Experimental Officer—J. D. Williams, D.D.A.
Experimental Officer—W. Straatmans, Dip.Ag., Dip.Trop.Agr.

Alpine Ecology—

Senior Research Officer—A. B. Costin, B.Sc.Agr. (Hons.).
Experimental Officer—D. J. Wimbush, B.Sc. (at Island Bend).

Agronomy—

Principal Research Officer—W. M. Willoughby, B.Sc.Agr.
Senior Research Officer—W. D. Andrew, M.Agr.Sc.

Research Officer—G. W. Arnold, M.Sc.
Research Officer—H. L. Davies, B.Sc.(Agr.) (Hons.).
Research Officer—J. Lipsett, B.Agr.Sc.(Hons.).

At Plant and Soils Laboratory, Bisbane, Queensland—
Associate Chief—J. Griffiths Davies, B.Sc., Ph.D.
Laboratory Secretary—A. G. A. Eyles, B.Sc.(Agric.).

Agrostology—
Principal Research Officer—T. P. Paltridge, B.Sc. (Hons.) (overseas with A.S.L.O., Washington).

Pasture Ecology—
Principal Research Officer—W. W. Bryan, M.Agr.Sc.
Principal Research Officer—N. H. Shaw, B.Agr. (Hons.) (overseas).
Research Officer—L. A. Edye, B.Agr.Sc.(Hons.).
Research Officer—F. K. van der Kley, Ing.Agr.

Plant Nutrition and Physiology—
Senior Research Officer—C. S. Andrew, M.Agr.Sc., B.Sc.(Hons.) (overseas).
Senior Research Officer—R. G. Coleman, B.Sc. (Agric.), Ph.D., D.I.C.
Research Officer—E. P. Henzell, B.Agr.Sc.(Hons.), D.Phil.

Plant Chemistry—
Research Officer—M. P. Hegarty, M.Sc., Ph.D.
Experimental Officer—Miss P. M. Thorne, B.Sc.
Experimental Officer—R. D. Court, B.Sc.

Ecology—
Senior Research Officer—J. E. Coaldrake, M.Sc. (overseas).
Experimental Officer—W. F. Ridley, B.Sc.

Genetics—
Senior Principal Research Officer—E. M. Hutton, B.Agr.Sc., D.Sc.
Research Officer—J. J. Yates, B.Sc.(Agric.) (Hons.).

Legume Bacteriology—
Principal Research Officer—D. O. Norris, D.Sc.(Agric.)

Plant Introduction—
Research Officer—E. H. Kipps, B.Sc.

At Cooper Laboratory, Lawes, Queensland—
Research Officer—R. Milford, B.Agr.Sc.

At Regional Pastoral Laboratory, Armidale, New South Wales—

Pasture Investigations—
Principal Research Officer—R. Roe, B.Sc.(Agric.).
Senior Research Officer—E. J. Hilder, B.Sc.(Agric.).
Senior Research Officer—K. Spencer, B.Sc.Agr. (Hons.), M.S.
Research Officer—J. E. Begg, B.Sc.Agr.(Hons.).
Research Officer—N. J. Barrow, M. Agr.Sc.
Research Officer—J. R. Freney, M.Sc. (overseas).
Research Officer—J. L. Wheeler, B.Sc., Ph.D.
Experimental Officer—B. E. Mottershead, B.Sc.
Experimental Officer—J. A. Thompson, B.Sc.(For.).

At Regional Pastoral Laboratory, Deniliquin, New South Wales—
Officer-in-charge—L. F. Myers, M.Agr.Sc.

Pasture Investigations—
Research Officer—J. L. Davidson, M.Agr.Sc.
Research Officer—O. B. Williams, M.Agr.Sc.
Research Officer—C. R. Kleinig, B.Ag.Sc.(Hons.).
Research Officer—R. H. Sedgley, M.Sc.
Experimental Officer—R. H. Crockford, A.R.M.T.C.
Experimental Officer—B. D. Millar, B.Sc.Agr.

Genetics—
Experimental Officer—Miss V. E. Rogers, B.A. (Hons.).

Agricultural Physics—
Principal Research Officer—D. A. de Vries, D.Sc.
Senior Research Officer—J. R. Philip, B.C.E. (overseas).
Experimental Officer—A. J. Peck, B.Sc.(Hons.).

At Regional Laboratory, Perth—

Pasture Investigations—
Principal Research Officer—R. C. Rossiter, D.Sc. (Agric.).
Senior Research Officer—P. G. Ozanne, B.Sc.(Agric.).
Research Officer—A. W. Humphries, B.Sc.Agric. (Hons.).
Experimental Officer—T. C. Shaw, B.Sc.
Experimental Officer—D. J. Kirton, B.Sc.(Agric.).

Plant Introduction—
Senior Research Officer—E. T. Bailey, B.Sc.(Hons.).

At "Glen Lossie" Field Station, Kojonup, Western Australia—
Senior Research Officer—E. R. Watson, M.Sc. (Agric.).
Experimental Officer—P. Lapins, Dip.Agronom.

At Tasmanian Regional Laboratory, Hobart—

Fruit Investigations—
Principal Research Officer—D. Martin, D.Sc.
Research Officer—T. L. Lewis, M.Sc.
Experimental Officer—J. Cerny, Dr.Tech.Sc.

At Applethorpe, Queensland—

Fruit Investigations—
Principal Research Officer—L. A. Thomas, M.Sc.

At Agricultural Research Institute, Wagga Wagga—
Research Officer—R. N. Oram, B.Ag.Sc.(Hons.).

At University of Melbourne—

Soil Chemistry—
Senior Research Officer—L. H. P. Jones, B.Agr.Sc., Ph.D. (overseas).

At University of Queensland, Brisbane—

Ecology—
Senior Research Officer—L. J. Webb, M.Sc., Ph.D.

At Irrigation Research Station, Griffith, New South Wales—

Weed Ecology—
Senior Research Officer—E. Levi, M.Sc. (overseas).

At Tobacco Research Institute, Mareeba, Queensland—
Director—D. W. Goodall, Ph.D., D.Sc. (overseas).
Research Officer—W. J. Lovett, B.Agr.Sc.
Research Officer—J. van der Harst, Ing.Agr.
Research Officer—P. J. Goodman, B.Sc., Ph.D.
Research Officer—N. K. Matheson, M.Sc., Ph.D.

32. DIVISION OF RADIOPHYSICS.

(Head-quarters: University Grounds, Sydney.)

Administration—
Chief—E. G. Bowen, O.B.E., M.Sc., Ph.D., D.Sc., F.A.A.
Assistant Chief—J. L. Pawsey, M.Sc., Ph.D., F.A.A., F.R.S.
Technical Secretary—A. J. Higgs, B.Sc.(Hons.).
Principal Research Officer—L. L. McCready, B.Sc., B.E.

Cloud and Rain Physics—
Principal Research Officer—J. Warner, B.Sc., B.E.
Principal Research Officer—P. Squires, M.A.
Principal Research Officer—E. J. Smith, M.B.E., B.Sc.(Eng.) (Hons.).
Senior Research Officer—G. A. Day.
Senior Research Officer—E. K. Bigg, M.Sc., Ph.D.
Senior Research Officer—A. A. Weiss, B.Sc.(Hons.), Ph.D.
Research Officer—E. E. Adderley, B.Sc.
Research Officer—S. Twomey, M.Sc., Ph.D.
Research Officer—J. W. Telford, B.Sc.(Hons.).
Research Officer—J. A. Warburton, B.Sc.(Hons.).
Research Officer—N. H. Fletcher, B.Sc., M.A., Ph.D.
Experimental Officer—K. J. Heffernan.
Experimental Officer—J. W. Smith, B.Sc.
Experimental Officer—K. G. Weir, A.S.T.C.

Radio Astronomy—

Senior Principal Research Officer—J. H. Piddington, M.Sc., B.E., Ph.D.
Senior Principal Research Officer—B. Y. Mills, B.Sc., M.E.
Principal Research Officer—W. N. Christiansen, D.Sc.
Principal Research Officer—J. P. Wild, M.A.
Principal Research Officer—F. J. Kerr, M.Sc., M.A.
Senior Research Officer—C. A. Shain, B.Sc.(Hons.).
Senior Research Officer—S. F. Smerd, B.Sc.(Hons.).
Research Officer—N. R. Labrum, B.Sc.(Hons.).
Research Officer—R. X. McGee, B.Sc.(Hons.).
Research Officer—E. R. Hill, M.Sc.
Research Officer—A. G. Little, B.Sc.
Research Officer—C. S. Gum, M.Sc., Ph.D.
Research Officer—A. W. L. Carter, B.Sc.(Hons.).
Research Officer—R. F. Mullaly, M.Sc., Ph.D.
Research Officer—B. R. Goddard, B.Sc., B.E.
Research Officer—D. S. Mathewson, M.Sc.
Visiting Research Fellow—R. Q. Twiss, M.A., Sc.D.
Visiting Research Fellow—C. M. Wade, B.A., M.A., Ph.D.
Experimental Officer—K. V. Sheridan, B.Sc., B.A.
Experimental Officer—K. R. McAlister, A.S.T.C.
Experimental Officer—J. V. Hindman.
Experimental Officer—J. D. Murray, B.Sc.(Eng.).
Experimental Officer—O. B. Slee, B.Sc.
Experimental Officer—M. M. Komesaroff, B.Sc.
Experimental Officer—M. W. Willing, A.R.M.T.C.

Radio Navigation and Propagation—

Principal Research Officer—M. Beard, B.Sc., M.E.
Senior Research Officer—F. F. Gardner, B.Sc., B.E., Ph.D.
Research Officer—D. E. Yabsley, B.Sc., B.E.
Experimental Officer—P. T. Hedges, A.S.T.C.
Experimental Officer—G. A. Chandler, B.E.

Semiconductors and Transistors—

Principal Research Officer—B. F. C. Cooper, B.Sc.(Hons.), B.E.
Senior Research Officer—L. W. Davies, B.Sc.(Hons.), D.Phil.
Research Officer—R. D. Ryan, B.Sc.(Hons.), B.E.
Experimental Officer—F. G. Tonking, A.S.T.C.
Experimental Officer—B. M. Bartlett, B.Sc.

Test and Development—

Experimental Officer—G. A. Wells, A.S.T.C.
Experimental Officer—T. E. Cousins, A.S.T.C.

Engineering Services—

Chief Drafting Officer—F. M. Carter.
Drafting Officer—H. F. Peddie, A.S.T.C.
Drafting Officer—J. R. Morris.

Officers Abroad—

Principal Research Officer—H. C. Minnett, B.Sc., B.E.
Principal Research Officer—T. Pearcey, B.Sc. (Hons.).
Senior Research Officer—J. A. Roberts, M.Sc., Ph.D.
Research Officer—J. S. Turner, M.Sc., Ph.D.
Research Officer—B. J. Robinson, M.Sc., Ph.D.

33. RADIO RESEARCH LABORATORIES.

(Head-quarters: Harben Vale, Camden, New South Wales.)

Chief Officer-in-charge—D. F. Martyn, D.Sc., Ph.D., A.R.C.S., F.A.A., F.R.S.
Senior Principal Research Officer—G. H. Munro, M.Sc., D.Sc.
Senior Research Officer—W. L. Price, B.Sc., B.E. (part-time).
Senior Research Officer—G. R. A. Ellis, B.Sc.(Hons.), Ph.D.
Research Officer—R. A. Duncan, B.Sc.(Hons.).
Experimental Officer—J. A. Harvey, B.Sc.
Experimental Officer—L. H. Heisler, B.Sc.
Experimental Officer—R. B. White, B.E.

34. DIVISION OF SOILS.

(Head-quarters: Waite Agricultural Research Institute, Adelaide.)

At Adelaide—

Administration—

Chief—J. K. Taylor, B.A., M.Sc., B.Sc.Agr.
Chief Clerk—F. W. Blanksby.
Librarian—P. H. Dawe.

Soil Survey and Pedology Section—

Senior Principal Research Officer—C. G. Stephens, D.Sc.
Principal Research Officer—K. H. Northcote, B.Ag.Sc.
Principal Research Officer—G. Blackburn, B.Ag.Sc.
Senior Research Officer—E. A. Jackson, B.Ag.Sc. (at Alice Springs).
Research Officer—C. B. Wells, B.Ag.Sc.
Senior Drafting Officer—P. D. Hooper.

Soil Chemistry Section—

Senior Principal Research Officer—C. S. Piper, D.Sc.
Principal Research Officer—A. C. Oertel, M.Sc.
Principal Research Officer—J. T. Hutton, B.Sc., A.S.A.S.M.
Senior Research Officer—H. C. T. Stace, M.Sc.
Senior Research Officer—B. M. Tucker, B.A., B.Sc.
Research Officer—M. Raupach, M.Sc.
Research Officer—K. G. Tiller, M.Sc.
Experimental Officer—M. P. C. de Vries, Ing.Agr.
Experimental Officer—A. R. P. Clarke, A.S.A.S.M.
Experimental Officer—R. M. McKenzie, B.Tech.
Experimental Officer—R. D. Bond, B.Tech.
Experimental Officer—J. B. Giles, B.Sc.

Soil Physics Section—

Senior Principal Research Officer—T. J. Marshall, M.Ag.Sc., Ph.D.
Senior Research Officer—J. W. Holmes, M.Sc.
Senior Research Officer—W. W. Emerson, B.A., Ph.D.
Senior Research Officer—E. L. Greacen, B.Sc.Agr., Ph.D.
Research Officer—C. G. Gurr, B.Sc.

Soil Microbiology Section—

Senior Principal Research Officer—R. J. Swaby, M.Sc., M.Ag.Sc., Ph.D.
Senior Research Officer—J. R. Harris, M.Sc.
Research Officer—J. N. Ladd, M.Sc. (on leave).
Research Officer—A. D. Rovira, B.Ag.Sc., Ph.D.

Soil Mechanics Section (at University of Melbourne)—

Principal Research Officer—G. D. Aitchison, M.E., Ph.D.
Research Officer—I. B. Donald, M.E.
Research Officer—R. H. G. Parry, M.E.Sc., Ph.D.
Experimental Officer—P. O. Morris, B.C.E.
Experimental Officer—C. J. Witherow, B.C.E.

Clay Mineralogy Section—

Senior Research Officer—K. Norrish, M.Sc., Ph.D.
Research Officer—E. W. Radoslovich, M.Sc., Ph.D.
Research Officer—J. A. Rausell Colom, D.Sc.
Research Officer—Mrs. L. E. R. Rogers, M.Sc.
Experimental Officer—R. M. Taylor, B.Sc.

At Brisbane—

Soil Survey and Pedology Section—

Principal Research Officer—G. D. Hubble, B.Ag.Sc.
Research Officer—G. G. Beckmann, B.Sc.
Research Officer—W. H. Litchfield, B.Sc.Agr. (seconded to Division of Land Research and Regional Survey).
Research Officer—C. J. de Mooy, Ing.Agr.
Research Officer—R. F. Isbell, M.Sc.
Experimental Officer—C. H. Thompson, Q.D.A.

Soil Physics Section—
Senior Research Officer—G. B. Stirk, B.Sc.
Experimental Officer—R. E. Prebble, B.Sc.

Soil Chemistry Section—
Principal Research Officer—A. E. Martin, B.Sc., F.R.I.C.
Senior Research Officer—R. S. Beckwith, B.Sc.
Experimental Officer—R. Reeve, Dip.Ind.Chem.
Experimental Officer—I. F. Fergus, B.Sc.
Experimental Officer—I. P. Little, B.Sc.Agr.

At Canberra—
Soil Survey and Pedology Section—
Principal Research Officer—B. E. Butler, B.Sc. (Agric.).
Senior Research Officer—R. Brewer, B.Sc.
Senior Research Officer—J. R. Sleeman, B.Ag.Sc.
Senior Research Officer—D. C. van Dijk, Ing.Agr., D.Sc.
Research Officer—P. H. Walker, B.Sc.Agr.
Research Officer—H. M. Churchward, B.Sc.Agr. (at Deniliquin).
Research Officer—J. A. Beattie, B.Sc.Agr. (at Griffith).
Experimental Officer—B. F. Breese, B.Sc.

Soil Chemistry Section—
Experimental Officer—H. J. Beatty, Dip.Ind.Chem.

Soil Physics Section—
Research Officer—D. S. McIntyre, M.Sc., Ph.D.
Experimental Officer—A. V. Blackmore, B.Sc. (on leave).

At Hobart—
Soil Survey and Pedology Section—
Principal Research Officer—K. D. Nicolls, B.Ag.Sc., B.Sc.
Research Officer—G. M. Dimmock, B.Sc.
Research Officer—J. Loveday, M.Ag.Sc. (on leave).

Soil Chemistry Section—
Experimental Officer—A. M. Graley, B.Sc.
Experimental Officer—J. L. Honeysett, B.Sc.

At Perth—
Soil Survey and Pedology Section—
Senior Research Officer—M. J. Mulcahy, B.Sc.
Research Officer—W. M. McArthur, B.Sc.
Experimental Officer—E. Bettenay, B.Sc.(Agric.).

Soil Chemistry Section—
Experimental Officer—A. G. Turton, B.Sc. (overseas).
Experimental Officer—F. J. Hingston, B.Sc.

35. Division of Tribophysics.

(Head-quarters: University of Melbourne.)

Chief—W. Boas, M.Sc., D.Ing., F.A.A.
Principal Research Officer—L. M. Clarebrough, B.Met.E., M.Eng.Sc., Ph.D.
Principal Research Officer—M. E. Hargreaves, B.Met.E., Ph.D.
Principal Research Officer—J. K. Mackenzie, B.A. (Hons.), B.Sc., Ph.D.
Principal Research Officer—A. J. W. Moore, B.Sc., Ph.D.
Senior Research Officer—A. J. Davis, B.Eng.
Senior Research Officer—A. K. Head, B.A.(Hons.), B.Sc., Ph.D.
Senior Research Officer—D. Michell, B.E.E.
Senior Research Officer—J. F. Nicholas, B.A.(Hons.), B.Sc.
Senior Research Officer—G. J. Ogilvie, B.Met.E., M.Eng.Sc., Ph.D.
Senior Research Officer—J. V. Sanders, B.Sc.(Hons.), Ph.D.
Senior Research Officer—Mrs. H. M. C. Sosnowsky, Ph.D.
Senior Research Officer—G. W. West, B.E.E., B.Sc.
Research Officer—Mrs. L. A. Bruce, B.Sc.(Hons.), Ph.D.
Research Officer—B. D. Cuming, M.Sc., Ph.D.
Research Officer—E. A. Faulkner, M.A.(Hons.).
Research Officer—E. Gillam, B.Sc., M.S.
Research Officer—D. F. Klemperer, B.Sc., Ph.D.
Research Officer—M. H. Loretto, B.Met.(Hons.).
Research Officer—K. Schroder, Ph.D.
Research Officer—H. G. Scott, B.A., Ph.D.
Research Officer—J. A. Spink, M.Sc.
Experimental Officer—G. R. Perger, F.R.M.T.C.
Experimental Officer—R. G. Sherwood, A.R.M.T.C.
Experimental Officer—E. D. Hondros, B.Sc.
Experimental Officer—H. Jaeger, A.R.A.C.I.
Experimental Officer—E. Lovegrove, A.R.M.T.C.
Experimental Officer—A. J. White, A.R.M.T.C.

36. Wildlife Survey Section.

(Head-quarters: Canberra, Australian Capital Territory.)

At Head-quarters, Canberra—
Officer-in-charge—F. N. Ratcliffe, O.B.E., B.A. (Hons.).
Senior Principal Research Officer—R. Carrick, B.Sc. (Hons.), Ph. D.
Sectional Secretary—F. N. Robinson, B.A.
Senior Research Officer—A. L. Dyce, B.Sc.Agr. (Hons.).
Senior Research Officer—H. J. Frith, B.Sc.Agr.
Senior Research Officer—M. E. Griffiths, M.Sc.
Research Officer—J. H. Calaby, Dip.App.Chem.
Research Officer—B. J. G. Marlow, B.Sc.(Hons.).
Research Officer—R. Mykytowycz, B.V.M., D.V.M.
Experimental Officer—I. C. R. Rowley, B.Agr.Sc.
Experimental Officer—S. J. J. F. Davies, B.A. (Hons.).
Experimental Officer—J. E. Bromell, B.Agr.Sc.
Experimental Officer—Mrs. C. F. Bennett, B.Sc.
Scientific Librarian—Mrs. E. M. Wylie, B.Sc.

At Perth, Western Australia—
Principal Research Officer—D. L. Serventy, B.Sc. (Hons.), Ph.D.
Research Officer—E. H. M. Ealey, M.Sc.

At Albury, New South Wales—
Senior Research Officer—K. Myers, B.Sc.(Hons.).
Research Officer—W. E. Poole, B.Sc.(Hons.).

At Armidale, New South Wales—
Senior Research Officer—B. V. Fennessy, B.Agr.Sc.
Experimental Officer—E. J. Waterhouse, B.Sc.Agr.

37. Wool Textile Research Laboratories.

Senior Officer-in-charge—F. G. Lennox, D.Sc.

At Wool Textile Research Laboratory, Melbourne—
Biochemistry Unit, 343 *Royal-parade, Parkville, Victoria*—
Officer-in-charge—F. G. Lennox, D.Sc.
Laboratory Secretary—C. Garrow, B.Com., D.P.A., A.A.S.A.
Senior Principal Research Officer—W. G. Crewther, M.Sc.
Principal Research Officer—R. D. B. Fraser, B.Sc. (Hons.), Ph.D.
Principal Research Officer—J. M. Gillespie, M.Sc. (overseas).
Principal Research Officer—M. A. Jermyn, M.Sc., Ph.D. (overseas).
Principal Research Officer—S. J. Leach, B.Sc.Tech., Ph.D.
Principal Research Officer—H. Lindley, B.A., Ph.D.
Principal Research Officer—T. A. Pressley, B.Sc.
Principal Research Officer—J. M. Swan, B.Sc., Ph.D.
Senior Research Officer—B. S. Harrap, M.Sc., Ph.D.
Senior Research Officer—I. J. O'Donnell, M.Sc.

Senor Research Officer—W. E. Savige, M.Sc., Ph.D.
Senior Research Officer—E. O. P. Thompson, M.Sc., Dip.Ed., Ph.D.
Senior Research Officer—E. F. Woods, M.Sc., A.R.M.T.C.
Research Officer—J. A. Maclaren, M.Sc., Ph.D.
Research Officer—T. P. MacRae, M.Sc.
Research Officer—B. Milligan, B.Sc.(Hons.), Ph.D.
Research Officer—G. E. Rogers, M.Sc., Ph.D.
Research Officer—C. M. Roxburgh, B.Sc., Ph.D.
Research Officer—P. H. Springell, M.A., Ph.D.
Research Officer—G. Youatt, B.Sc., Ph.D.
Senior Experimental Officer—J. P. E. Human, M.Sc., Ph.D.
Experimental Officer—A. B. McQuade, B.Sc.
Experimental Officer—R. J. Rowlands, B.Sc.
Experimental Officer—K. I. Wood, A.R.M.T.C.
Experimental Officer—L. M. Dowling, B.Sc.
Experimental Officer—I. W. Stapleton, Dip.Chem.

At Wool Textile Research Laboratory, Sydney—
Physics and Engineering Unit, The Hermitage, 338 *Blaxland-road, Ryde, New South Wales—*
Officer-in-charge—V. D. Burgmann, B.Sc., B.E.
Technical Secretary—H. W. M. Lunney, B.Sc., B.E.
Principal Research Officer—M. Feughelman, B.Sc., A.S.T.C.
Principal Research Officer—J. G. Downes, B.Sc.
Principal Research Officer—N. F. Roberts, M.Sc.
Senior Research Officer—H. W. Holdaway, B.Sc., B.E.
Senior Research Officer—Mrs. K. R. Makinson, B.A.
Research Officer—M. W. Andrews, B.Sc., Ph.D.
Research Officer—K. Baird, M.Sc., Ph.D.
Research Officer—E. G. Bendit, B.Sc.(Eng.), M.Sc.
Research Officer—E. F. Denby, B.Sc., Ph.D., D.I.C.
Research Officer—A. R. Haly, M.Sc.
Research Officer—J. F. P. James, M.Sc. (overseas).
Research Officer—Miss V. Laws, M.Sc.
Research Officer—D. T. Liddy, B.Sc.
Research Officer—P. Nordon, B.Sc., A.S.T.C. (overseas).
Research Officer—I. M. Stuart, M.Sc.
Research Officer—I. C. Watt, M.Sc., Ph.D.
Experimental Officer—J. E. Algie, B.E., A.S.T.C.
Experimental Officer—Miss J. C. Griffith, M.Sc., A.S.T.C.
Experimental Officer—B. G. Leary, B.E., A.S.T.C.
Experimental Officer—G. L. Stott, A.S.T.C.
Experimental Officer—R. H. Kennett, A.S.T.C.
Experimental Officer—B. H. Mackay, A.S.T.C.
Experimental Officer—G. B. McMahon, B.Sc.
Experimental Officer—B. J. Rigby, M.Sc., A.S.T.C. (overseas).
Experimental Officer—E. Sebestyen, Dip.M.E., D.Sc.
Librarian—Miss H. G. Barr, B.A.
Senior Drafting Officer—C. W. Quinnell, A.S.T.C.

At Wool Textile Research Laboratory, Geelong, Victoria—
Officer-in-charge—M. Lipson, B.Sc., Ph.D.
Technical Secretary—T. Topham, A.T.I.
Principal Research Officer—G. W. Walls, B.Sc.
Senior Research Officer—A. J. Farnworth, M.Sc., Ph.D., A.G.Tech.Inst.
Senior Research Officer—G. F. Wood, B.Sc., Ph.D.
Research Officer—C. A. Anderson, B.Sc. (overseas).
Research Officer—J. H. Bradbury, M.Sc., Ph.D.
Research Officer—J. Delmenico, B.Sc. (overseas).
Research Officer—D. E. Henshaw, B.Sc.
Research Officer—J. R. McPhee, B.Sc., Ph.D.
Research Officer—W. V. Morgan, B.Sc.
Research Officer—G. H. Tauber, Dipl.Chem., Ph.D.
Research Officer—D. S. Taylor, B.A., B.Sc., Ph.D.
Experimental Officer—M. A. Higgins, A.G.Inst.Tech.
Experimental Officer—B. O. Lavery.
Experimental Officer—A. R. W. Lee, B.Sc., Dip.Ed.
Experimental Officer—B. D. Harding, A.G.Inst. Tech.
Experimental Officer—J. D. Leeder, A.G.Inst.Tech.
Experimental Officer—D. C. Shaw, B.Sc.
Experimental Officer—G. C. West, A.G.Inst.Tech.
Drafting Officer—W. E. O. Knothe, Dip.Mech.Eng.

XXXIV. PUBLISHED PAPERS.

The following papers have been published during the year. Letters Patent granted to the Organization during the year are also included.

1. ANIMAL GENETICS SECTION.

Allen, T. E., *and* Grigg, G. W. (1957).—Sperm transport in the fowl. *Aust. J. Agric. Res.* 8: 788-99.

Dun, R. B. (1958).—Growth of the mouse coat. VI. Distribution and number of vibrissae in the house mouse. *Aust. J. Biol. Sci.* 11: 95-105.

Fraser, A. S. (1957).—Simulation of genetic systems by automatic digital computers. I. Introduction. *Aust. J. Biol Sci.* 10: 484-91.

Fraser, A. S. (1957).—Simulation of genetic systems by automatic digital computers. II. Effects of linkage on rates of advance under selection. *Aust. J. Biol. Sci.* 10: 492-500.

Fraser, A. S. (1958).—Monte Carlo analyses of genetic models. *Nature* 181: 208-9.

Fraser, A. S., *and* Short, B. F. (1958).—Studies of sheep mosaic for fleece type. I. Patterns and origin of mosaicism. *Aust. J. Biol. Sci.* 11: 200-8.

Grigg, G. W. (1958).—Competitive suppression and the detection of mutations in microbial populations. *Aust. J. Biol. Sci.* 11: 69-84.

Nay, T., *and* Dowling, D. F. (1957).—Size of sweat glands in Shorthorn strains and Zebu x Shorthorn crossbred cattle. *Aust. J. Agric. Res.* 8 : 385-93.

Rendel, J. M. (1958).—Effect of age on the relationship between coincidence and crossing over in *Drosophila melanogaster. Genetics* 43 (2).

Sheldon, B. L. (1958).—The effect of temperature on the mutation rate in *Drosophila melanogaster. Aust. J. Biol. Sci.* 11 : 85-94.

Short, B. F., Fraser, A. S., *and* Carter, H. B. (1958).—Effect of level of feeding on the variability of fibre diameter in four breeds of sheep. *Aust. J. Agric. Res.* 9 : 229-36.

Short, B. F., *and* Sobey, W. R. (1957).—The effect of sex on skin grafts within inbred lines of mice. *Transplantation Bull.* 4 : 110-12.

Sobey, W. R., *and* Adams, K. M. (1957).—Studies in anaphylaxis. II. Dose responses to bovine plasma albumin in mice. *Aust. J. Biol. Sci.* 10 : 475-83.

Sobey, W. R., *and* Claringbold, P. (1957).—Studies in anaphylaxis. I. Quantitative scores for anaphylaxis in mice. *Aust. J. Biol. Sci.* 10 : 360-4.

Sobey, W. R., Claringbold, P., *and* Adams, K. M. (1957).—Inheritance of antibody response. III. Heritability of response to sheep red cells. *Aust. J. Biol. Sci.* 10 : 367-73.

Stephenson, S. K. (1958).—Wool follicle developments in the New Zealand Romney and *N*-type sheep. II. Follicle population density during foetal development. *Aust. J. Agric. Res.* 9 : 138-60.

2. DIVISION OF ANIMAL HEALTH AND PRODUCTION.

Alexander, G., *and* McCance, I. (1958).—Temperature regulation in the new-born lamb. I. Changes in rectal temperature within the first six hours of life. *Aust. J. Agric. Res.* 9 : 339-47.

Allen, T. E., *and* Grigg, G. W. (1957).—Sperm transport in the fowl. *Aust. J. Agric. Res.* 8 : 788-99.

Allen, T. E., *and* Skaller, F. (1957).—Mortality in an unculled population of four generations of chickens during their first laying year. *Aust. Vet. J.* 34: 61-70.

Barrett, J. F. (1957).—Relationship of various culling criteria in ewes to subsequent lamb-marking percentages. *Proc. Aust. Soc. Anim. Prod.* 1 : 21-3.

Braden, A. W. H. (1957).—Differences between inbred strains of mice in the morphology of the gametes. *Anat. Rec.* 127 : 270-1.

Braden, A. W. H. (1957).—Relationship between the diurnal light cycle and the times of ovulation in mice. *J. Exp. Biol.* 34 : 177-88.

Braden, A. W. H. (1958).—Influence of time of mating on the segregation ratio of alleles at the T locus in the house mouse. *Nature* 181 : 786-7.

Briggs, P. K. (1957).—The utilization of low quality roughage by sheep. *Proc. Aust. Soc. Anim. Prod.* 1 : 72-9.

Briggs, P. K., Hogan, J. P., *and* Reid, R. L. (1957).—Effect of volatile fatty acids, lactic acid, and ammonia on rumen pH in sheep. *Aust. J. Agric. Res.* 8 : 674-90.

Bull, L. B., Dick, A. T., *and* McKenzie, J. S. (1958).—The acute toxic effects of heliotrine and lasiocarpine, and their *N*-oxides, on the rat. *J. Path. Bact.* 75 : 17-25.

Campbell, B. L. (1957).—Use of vitamin A supplements for sheep. *Proc. Aust. Soc. Anim. Prod.* 1 : 46-50.

Carter, H. B., Turner, Helen Newton, *and* Hardy, Margaret H. (1958).—The influence of various factors on some methods of estimating fibre and follicle population density in the skin of Merino sheep. I. Methods of delineating area of natural skin. *Aust. J. Agric. Res.* 9 : 237-51.

Chapman, R. E., *and* Young, S. S. Y. (1957).—Study of wool production per unit area of skin in Australian Merino sheep. *Aust. J. Agric. Res.* 8 : 723-32.

Dolling, C. H. S. (1957).—The inheritance of horns in sheep. *Proc. Aust. Soc. Anim. Prod.* 1 : 161-4.

Doney, J. M. (1958).—Effects of inbreeding on four families of Peppin Merinos. II. The influence of inbreeding on age trends. *Aust. J. Agric. Res.* 9 : 252-9.

Dunlop, A. A., *and* Hayman, R. H. (1958).—Differences among Merino strains in resistance to fleece-rot. *Aust. J. Agric. Res.* 9 : 260-6.

Durie, P. H. (1957).—The relationship between intestinal fat cell content and infectivity of the third stage larvae of the bovine stomach worm *Haemonchus placei* (Place 1893) Ransom 1911. *Aust. Vet. J.* 33 : 305.

Farrington, K. J., *and* Warburton, W. K. (1957).—Studies in the chemistry of phenothiazine. III. Attempts to prepare some pentacyclic compounds. *Aust. J. Chem.* 10 : 502-4.

Franklin, M.C. (1957).—Presidential address. *Proc. Aust. Soc. Anim. Prod.* 1 : 7-17.

Ferguson, K. A. (1957).—Efficiency of wool growth. *Proc. Aust. Soc. Anim. Prod.* 1 : 58-62.

Gallagher, C. H. (1957).—The pathology and biochemistry of copper deficiency. *Aust. Vet. J.* 33 : 311-17.

Gordon, H. McL. (1957).—Helminthic diseases. *Advanc. Vet. Sci.* 3 : 287-351.

Gordon, H. McL. (1958).—The epidemiology of helminthosis in sheep in winter rainfall regions of Australia. 2. Western Australia. *Aust. Vet. J.* 34 : 5-19.

Gregory, T. S. (1957).—Contagious bovine pleuropneumonia; report of investigations in Australia. *Bull. Epiz. Dis. Afr.* 5 : 187-98.

Grigg, G. W. (1957).—The structure of stored sperm in the hen and the nature of the release mechanism. *Poult. Sci.* 36 : 450-1.

Hamilton, F. J. (1957).—A tourniquet for controlling haemorrhage from the liver during experimental biopsies and lobe resection in sheep. *Aust. Vet. J.* 33 : 273-6.

Hayman, R. H., *and* Nay, T. (1958).—Sweat glands in Zebu (*Bos indicus* L.) and European (*B. taurus* L.) cattle. II. Effects of season and exercise on sweat gland volume. *Aust. J. Agric. Res.* 9 : 385-90.

Hogan, J. P. (1957).—The removal of nitrogen at different levels from the alimentary tract of the sheep. *J. Physiol.* 139 : 25-6P.

Koch, Judith H., Rogers, W. P., Dwyer, F. P., *and* Gyarfas, Eleanora C. (1957).—The metabolic fate of tris-1, 10-phenantroline-106 ruthenium (II) perchlorate, a compound with anticholinesterase and curare-like activity. *Aust. J. Biol. Sci.* 10 : 342-50.

Lyne, A. G. (1957).—The development of the epidermis and hair canals in the Merino sheep foetus. *Aust. J. Biol. Sci.* 10: 390-7.

Lyne, A. G. (1957).—The development of wool in Merino sheep. *Wool Technol.* 4 : 53-6.

Lyne, A. G., *and* Verhagen, A. M. W. (1957).—Growth of the marsupial *Trichosurus vulpecula* and a comparison with some higher mammals. *Growth* 21 : 167-95.

McDonald, I. W., *and* Hall, R. J. (1957).—The conversion of casein to microbial proteins in the rumen. *Biochem. J.* 67 : 400-5.

McKenzie, J. S. (1958).—Some pharmacological properties of pyrrolizidine alkaloids and their relationship to chemical structure. *Aust. J. Exp. Biol. Med. Sci.* 36 : 11-21.

Murray, M. D. (1957).—The distribution of the eggs of mammalian lice on their hosts. 3. The distribution of the eggs of *Damalinia ovis* (L.) on the sheep. *Aust. J. Zool.* 5 : 173-82.

Murray, M. D. (1957).—The distribution of the eggs of mammalian lice on their hosts. 4. The distribution of the eggs of *Damalinia equi* (Denny) and *Haematopinus asini* (L.) on the horse. *Aust. J. Zool.* 5 : 183-7.

Panaretto, B. A. (1957).—Beef cattle investigations in the southern States of Australia. *Proc. Aust. Soc. Anim. Prod.* 1 : 126-9.

Plackett, P. (1957).—Depolymerization of ribonucleic acid by extracts of *Asterococcus mycoides*. *Biochem. Biophys. Acta* 26 : 664-5.

Radford, H. M., *and* Watson, R. H. (1957).—Influence of rams on ovarian activity and oestrus in Merino ewes in the spring and early summer. *Aust. J. Agric. Res.* 8 : 460-70.

Reid, R. L., Hogan, J. P., *and* Briggs, P. K. (1957).—The effect of diet on individual volatile fatty acids in the rumen of sheep, with particular reference to the effect of low rumen pH and adaptation on high-starch diets. *Aust. J. Agric. Res.* 8 : 691-710.

Riek, R. F., *and* Keith, R. K. (1957).—Studies on anthelmintics for cattle. I. The efficiency of toluene with special reference to the hookworm *Bunostomum phlebotomum* (Railliet 1900). *Aust. Vet. J.* 33 : 162-8.

Riek, R. F., *and* Keith, R. K. (1957).—Studies on anthelmintics for cattle. II. The efficiency of 1 : 8-dihydroxyanthraquinone. *Aust. Vet. J.* 33 : 169-73.

Riek, R. F., *and* Keith, R. K. (1958).—Studies on anthelmintics for cattle. III. The efficiency of some piperazine compounds. *Aust. Vet. J.* 34 : 1-4.

Riek, R. F., *and* Keith, R. K. (1958).—Studies on anthelmintics for cattle. IV. The organic phosphorus compound 0,0-dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate (Bayer "L13/59"). *Aust. Vet. J.* 34 : 93-103.

Roberts, N. F., *and* Dunlop, A. A. (1957).—Relation between crimp and fineness in Australian Merinos. *Aust. J. Agric. Res.* 8 : 524-46.

Roberts, F. H. S. (1957).—The incidence and abundance of the gastro-intestinal helminths of cattle in the Tooradin district of south-eastern Victoria. *Aust. Vet. J.* 33 : 174.

Roberts, F. H. S. (1957).—Reactions of calves to infestation with the stomach worm *Haemonchus placei* (Place 1893) Ransom 1911. *Aust. J. Agric. Res.* 8 : 740-67.

Schinckel, P. G. (1957).—Relationship between follicle number and wool production. *Aust. J. Agric. Res.* 8 : 512-23.

Short, B. F., Fraser, A. S., *and* Carter, H. B. (1958).—Effect of level of feeding on the variability of fibre diameter in four breeds of sheep. *Aust. J. Agric. Res.* 9 : 229-36.

Short, B. F., *and* Sobey, W. R. (1957).—Effect of sex on skin grafts within inbred lines of mice. *Transplantation Bull.* 4 : 110-12.

Simmonds, R. A. (1957).—Studies on the sheath of fourth stage larvae of the nematode parasite *Nippostrongylus muris. Exp. Parasit.* 7 : 14-22.

Skaller, F. (1957).—The Hagedoorn "nucleus-system" of breeding—a critical evaluation based on an experiment with poultry. *Proc. Aust. Soc. Anim. Prod.* 1 : 165-76.

Skaller, F. (1957).—There is money in eggs. *Aust. Ctry. Mag.* 3 : 20-1.

Skaller, F. (1957).—The C.S.I.R.O. Poultry Research Centre, Werribee. C.S.I.R.O. Aust. Div. Anim. Hlth. Prod. Tech. Pap. No. 2.

Southcott, W. H., *and* Begg, J. E. (1957).—Ratio of sown to native pastures in sheep production. *Proc. Aust. Soc. Anim. Prod.* 1 : 33.

Symons, L. E. A. (1957).—Pathology of infestation of the rat with *Nippostrongylus muris* (Yokogawa). I. Changes in the water content, dry weight, and tissues of the small intestine. *Aust. J. Biol. Sci.* 10 : 374-83.

Thomas, J. H. (1957).—The eradication of contagious footrot of sheep. *Aust. Vet. J.* 33 : 263-6.

Thomas, J. H. (1958).—The treatment of contagious footrot of sheep with special reference to the value of terramycin. *Aust. Vet. J.* 34 : 33-7.

Turner, Helen Newton (1957).—Breeding plans for sheep—past and possible progress. *Proc. Aust. Soc. Anim. Prod.* 1 : 100-15.

Warburton, W. K. (1957).—Arylthiathiolium salts and *o*-aminoaryl thiols. The "Herz reaction". *Chem. Rev.* 57 : 1011-20.

Watson, R. H. (1957).—Wastage in reproduction in Merino sheep: an outline of recent work with particular reference to southern Australia. *Aust. Vet. J.* 33 : 307-10.

Watson, R. H. (1957).—Some gaps in our knowledge of the seasonal variation in reproductive activity of ewes of Merino and related breeds. *Proc. Aust. Soc. Anim. Prod.* 1 : 82-7.

Weston, R. H. (1957).—Determination of relative efficiencies of wool production by Merino strains in the field. *Proc. Aust. Soc. Anim. Prod.* 1 : 57.

Whitlock, H. V. (1957).—A technique for staining and counting *Syphacia obvelata* in the faeces and ingesta of mice. *J. Helminth.* 31 : 131-4.

Vignais, P., Gallagher, C. H., *and* Zabin, I. (1958).—Activation and oxidation of long chain fatty acids by rat brain. *J. Neurochem.* 2 : 283-7.

3. DIVISION OF BIOCHEMISTRY AND GENERAL NUTRITION.

Dawbarn, Mary C., Hine, Denise C., *and* Smith, Jean (1957).—Determination of vitamin B_{12} activity in the organs and excreta of sheep. V. The effect of cobalt deficiency on the vitamin B_{12} content of the blood plasma. *Aust. J. Exp. Biol. Med. Sci.* 35: 273-6.

Dawbarn, Mary C., Hine, Denise C., *and* Smith, Jean (1957).—Determination of vitamin B_{12} activity in the organs and excreta of sheep. VI. Vitamin B_{12} activity in portal blood. *Aust. J. Exp. Biol. Med. Sci.* 35 : 321-6.

Dewey, D. W., Lee, H. J., *and* Marston, Hedley R. (1958).—Provision of cobalt to ruminants by means of heavy pellets. *Nature* 181 : 1367-71.

Hine, Denise C., Dawbarn, Mary C., *and* Smith, Jean (1957).—Effect of copper on the response to vitamin B_{12} and methionine of a mutant strain of *Escherichia coli:* a modification of the basal medium. *Aust. J. Exp. Biol. Med. Sci.* 35 : 267-72.

Hine, Denise C., Dawbarn, Mary C., *and* Smith, Jean (1958).—Influence of the medium on the potency of vitamin B_{12} active factors in a tube assay with *Escherichia coli* mutant. *Aust. J. Exp. Biol. Med. Sci.* 36 : 5-10.

Jones, G. B. (1957).—Estimation of vanadium in plant materials. *Analyt. Chem. Acta* 17 : 254-8.

Lee, H. J., Kuchel, R. E., Good, B. F., *and* Trowbridge, R. F. (1957).—Aetiology of phalaris staggers in sheep. III. The preventive effect of various oral dose rates of cobalt. *Aust. J. Agric. Res.* 8 : 494-501.

Lee, H. J., Kuchel, R. E., Good, B. F., *and* Trowbridge, R. F. (1957).—Aetiology of phalaris staggers in sheep. IV. The site of preventive action and its specificity to cobalt. *Aust. J. Agric. Res.* 8 : 502-11.

Marston, H. R.—Means for supplying small amounts of nutritional or therapeutic substances to ruminants. Southern Rhodesian Pat. 533 157, Northern Rhodesian Pat. N.R. 738.

Peirce, A. W. (1957).—Studies on salt tolerance of sheep. I. Tolerance of sheep for sodium chloride in the drinking water. *Aust. J. Agric. Res.* 6 : 711-22.

Riceman, D. S., *and* Jones, G. B. (1958).—Distribution of zinc and copper in subterranean clover (*Trifolium subterraneum* L.) grown in culture solutions supplied with graduated amounts of zinc. *Aust. J. Agric. Res.* 9 : 73-122.

Weller, R. A. (1957).—Amino acid composition of hydrolysates of microbial preparations from the rumen of sheep. *Aust. J. Biol. Sci.* 10 : 384-9.

4. DIVISION OF BUILDING RESEARCH.

Ballantyne, E. R., *and* Spencer, J. W. (1957).—Temperatures of bituminous roof surfaces. Bull. Amer. Soc. Test. Mat. No. 223 : 69-73.

Beresford, F. D., *and* Blakey, F. A. (1957).—Plastic shrinkage. *Proc. Amer. Concr. Inst.* 53 : 1342-3.

Blakey, F. A. (1957).—Die plastischen Formanderungen von Gipskorpen. *Zement-Kalk-Gips* 10 : 368-9.

Blakey, F. A. (1957).—Some considerations of the cracking or fracture of concrete. *Civ. Engng., Lond.* 52 : 1000-3.

Blakey, F. A. (1958).—Control testing of concrete. *Constr. Rev.* 31 (3) : 23-4.

Blakey, F. A., *and* Hill, R. D. (1957).—Expanded shale or clay concrete. *Proc. Amer. Concr. Inst.* 54 : 422-3.

Bright, J. E.—Improved means for calcining gypsum. Aust. Pat. 211405.

Demediuk, Thaisa, *and* Cole, W. F. (1957).—A study on magnesium oxysulphates. *Aust. J. Chem.* 10 : 287-94.

Demediuk, Thaisa, *and* Cole, W. F. (1958).—On the exothermic reaction of metakaolin between 950° and 1000° C. *Nature* 181 : 1400-1.

Hill, R. D. (1958).—The long-term expansion of perlite plaster and concrete. *Aust. J. Appl. Sci.* 9 : 141-62.

Lippert, W. K. R. (1957).—Sound propagation in ducts with side branches. *Acustica* 7 : 137-45.

Lippert, W. K. R. (1957).—A property of multi-terminal acoustical junctions. *Acustica* 7 : 234-40.

Milne, Angela, A. (1958).—The expansion of fired kaolins when autoclaved and the effect of certain additives. *Trans. Brit. Ceram. Soc.* 57 : 148-60.

Muncey, R. W. (1958).—Calculations of lunar temperatures. *Nature* 181 : 1458-9.

Muncey, R. W., *and* Watterson, G. A. (1957).—Heating of surfaces by buried pipes: calculation of the steady and periodical states. *Aust. J. Appl. Sci.* 8 : 271-81.

Powell, D. A. (1958).—The thickening of slurries of gypsum plaster. *Aust. J. Appl. Sci.* 9 : 24-35.

Ridge, M. J. (1958).—The growth of crystals during setting of gypsum plaster. *Aust. J. Appl. Sci.* 9 : 163-6.

5. COAL RESEARCH SECTION.

Brooks, J. D., Durie, R. A., *and* Sternhell, S. (1958).—Chemistry of brown coal. II. Infra-red spectroscopic studies. *Aust. J. Appl. Sci.* 9 : 63-80.

Brooks, J. D., *and* Sternhell, S. (1957).—Chemistry of brown coal. I. Oxygen-containing functional groups in Victorian brown coals. *Aust. J. Appl. Sci.* 8 : 206-21.

Brooks, J. D., *and* Sternhell, S. (1958).—The action of alkalies on low-rank coals. *Fuel, Lond.* 37: 124-5.

Brown, H. R. (1957).—World energy trends in relation to Australia's fuel problems. *J. Inst. Fuel* 30 : 387-94.

Durie, R. A., Lack, Ruth E., *and* Shannon, J. S. (1957).—Chemistry of polynuclear compounds. I. The infra-red spectra of some polynuclear quinones and polynuclear aromatic hydrocarbons. *Aust. J. Chem.* 10 : 429-47.

Durie, R. A., *and* Murray, Agnes (1957).—A study of the infra-red absorption spectra of soils. *Aust. J. Appl. Sci.* 8 : 335-8.

Durie, R. A., *and* Shannon, J. S. (1958).—Chemistry of polynuclear compounds. II. The behaviour in concentrated sulphuric acid solution and absorption spectra of some polynuclear quinones. *Aust. J. Chem.* 11 : 168-88.

Durie, R. A., *and* Shannon, J. S. (1958).—Chemistry of polynuclear compounds. III. The structures and absorption spectra of 1,1′-dianthrimide and indanthrone. *Aust. J. Chem.* 11 : 189-99.

Kirov, N. Y., *and* Szpindler, G. (1958).—Structure and permeability of fuel beds: the influence of some physical factors. *J. Inst. Fuel* 31 : 63-71.

Waters, P. L. (1958).—New types of recording differential thermobalances. *J. Sci. Instrum.* 35 : 41-4.

6. DAIRY RESEARCH SECTION.

Conochie, J. (1958).—Stability of sodium ascorbate in canned unsweetened evaporated milk. *Aust. J. Dairy Tech.* 13 : 80.

Conochie, J., *and* Wilkinson, R. A. (1958).—Stability of vitamin A and carotene in fortified sweetened condensed milk. *Aust. J. Dairy Tech.* 13 : 27-8.

Czulak, J. (1958).—Mechanization of Cheddar cheese manufacture. *Dairy Engng.* 75 : 67-71.

Czulak, J., Freeman, N. H., *and* Chapman, H. L. C. (1958).—Mechanization of milling, salting, and hooping in Cheddar cheese manufacture. *Aust. J. Dairy. Tech.* 13 : 18-22.

Czulak, J., *and* Hammond, L. A. (1958).—"Cheedam"—a new variety of hard cheese. *Aust. J. Dairy Tech.* 13 : 23-5.

Czulak, J., *and* Hammond, L. A.—Cheese-curd fusing machine. South African Pat. 649/57, Aust. Pat. 211571.

Day, E. A.,* Forss, D. A., *and* Patton, S.* (1957).—Flavour and odour defects of gamma-irradiated skim milk. Part I.—Preliminary observations and the role of volatile carbonyl compounds. *J. Dairy Sci.* 40 : 922-31.

Day, E. A.,* Forss, D. A., *and* Patton, S.* (1957).—Flavour and odour defects of gamma-irradiated skim milk. Part II.—Identification of volatile components by gas chromatography and mass spectrometry. *J. Dairy Sci.* 40 : 932-41.

Forss, D. A. (1957).—Facts on flavour. *Aust. J. Dairy Tech.* 12 : 120-6.

Forss, D. A. (1957).—Simple expedient for hot micro-filtration. *Chem. Anal.* 46 (1) : 11.

Forss, D. A. (1958).—Recently developed laboratory techniques in the study of food flavours. *Food Tech. in Aust.* 10 : 15, 17, 19, 21, 23, 80, 83.

Forss, D. A., *and* Dunstone, E. A. (1957).—Change of 2,4-dinitrophenyl-hydrazones on alumina and silica gel chromatographic columns. *Aust. J. Chem.* 10 : 506-8.

Forss, D. A., *and* Dunstone, E. A. (1958).—Detection of carbonyl compounds in benzene. *Chem. & Ind.* 1958 : 127-8.

Forss, D. A., *and* Stark, W. (1958).—Two types of gas chromatographic apparatus. *Proc. Roy. Aust. Chem. Inst.* 25 : 2016.

Hills, G. Loftus (1957).—Export of butter and cheese to Great Britain; some technical aspects of shipping and handling practices. *Aust. J. Dairy Tech.* 12 : 127-33.

Hills, G. Loftus (1958).—Dairy research in Australia, 1952-57. *Dairy Sci. Abtr.* 20 (4): 267-80.

King, N. (1958).—Fluorescence microscopic observations of casein in milk, curd and cheese. *J. Dairy Res.* 25 : 205-10.

King, N. (1958).—Die Anwendung mikroskopischer Methoden bei der Untersuchung von Milchpulver. *Fette u. Seif Ernähr Industr.* 60 : 299.

King, N., *and* Czulak, J. (1958).—Fibrous structure in cheese curd. *Nature* 181 : 113-14.

Kumetat, K. (1958).—Upgrading proteins. *Food Tech. in Aust.* 10 : 119, 121, 123, 125.

Kumetat, K.—Method of producing egg substitutes for use in the production of sponges, cakes and similar baked goods. French Pat. 1109840.

Kumetat, K., *and* Beeby, R. (1957).—Influence of processing on the protein-sugar reaction. *Dairy Ind.* 22 : 642.

---

* Pennsylvania State University.

Morgan, M. E.,[*] Forss, D. A., *and* Patton, S.[†] (1957).—Volatile carbonyl compounds produced in skim milk by high-heat treatment. *J. Dairy Sci.* 40 : 5718.

Pont, E. G. (1958).—Effect of storage temperature on the keeping quality of butter. *Refrig. J.* 11 (7): 24-5, 27, 31.

Pont, E. G., *and* Gunnis, L. F.[‡] (1958).—The effect of temperature on the keeping quality of butter in cold storage. *Aust. J. Dairy Tech.* 13 : 68.

Wilkinson, R. A., *and* Conochie, J. (1958).—Stability of vitamin A in reconstituted fortified non-fat milk solids. Part I.—Effect of heat. *Aust. J. Dairy Tech.* 13 : 29-31.

Wilkinson, R. A., *and* Conochie, J. (1958).—Determination of vitamin A in milk and milk products. *Aust. J. Dairy Tech.* 13 : 32-7.

Wilkinson, R. A., *and* Conochie, J. (1958).—The stability of vitamin A in reconstituted fortified non-fat milk solids. Part II.—The effect of light. *Aust. J. Dairy Tech.* 13 : 74.

7. Division of Electrotechnology.

Cassidy, G. J. A. (1958).—Radio Doppler measurements on the Russian satellites at the National Standards Laboratory. *Proc. Instn. Radio Engrs. Aust.* 19 : 105.

Dryden, J. S., *and* Meakins, R. J. (1957).—Dielectric relaxation process in lithium, sodium, and potassium halides. *Disc. Faraday Soc. No.* 23 : 39.

Hawes, F. C.[§] (1957).—A recurrent surge oscillograph for surge-voltage distribution measurements on transformers. *Proc. Instn. Radio Engrs. Aust.* 18 : 462.

Medina, L. (1958).—A simple device for the alleviation of speech defects. *Proc. Instn. Radio Engrs. Aust.* 19 : 120.

O'Dwyer, J. J.[||] (1957).—The high temperature dielectric breakdown of alkali halides. *Proc. Phys. Soc. Lond.* B 70 : 761.

Palmer, T. M. (1958).—Decade flux linkage generators. *J. Sci. Instrum.* 35 : 139.

Posener, D. W. (1958).—Coupling of nuclear spins in molecules. *Aust. J. Phys.* 11 : 1.

Worthley, B.,[¶] Thompson, A. M., and Tooze, M. J.[¶] (1957).—Precision charge comparison for the standardization of X-ray dosemeters. *Aust. Appl. Sci.* 8 : 261.

8. Engineering Section.

Czulak, J., Freeman, N. H., *and* Chapman, H. L. C. (1958).—Mechanization of milling, salting and hooping in cheddar cheese manufacture. *Aust. J. Dairy Tech.* 13 : 18-22.

McClelland, J. H., *and* Spielrein, R. E. (1957).—An investigation of the ultimate bending strength of some common pasture plants. *J. Agric. Engng. Res.* 2 (4): 288-92.

McClelland, J. H., *and* Spielrein, R. E. (1958).—A study of some design factors affecting the performance of mower knives. *J. Agric. Engng. Res.* 3 : 137-46.

9. Division of Entomology.

Bailey, S. W. (1957).—Air-tight storage of grain: its effects on insect pests. III. *Calandra oryzae*. *Aust. J. Agric. Res.* 3 : 595-603.

Bailey, S. W. (1958).—The position of Khapra beetle in Australia. *F.A.O. Plant Prot. Bull.* 6 (5) : 1-2.

Bailey, S. W., *and* McCabe, B. (1957).—A controller for a light source. *Bull. Ent. Res.* 48 : 463-5.

Barton Browne, L. B. (1957).—The effect of light on the mating behaviour of the Queensland fruit fly *Strumeta tryoni*. *Aust. J. Zool.* 5 : 145-58.

Barton Brown, L. B. (1957).—An investigation of the low frequency of mating of the Queensland fruit fly *Strumeta tryoni*. *Aust. J. Zool.* 5 : 159-63.

Barton Browne, L. B. (1958).—The frequency of mating of the Australian sheep blowfly *L. cuprina*. *Aust. J. Sci.* 20 : 185.

Barton Browne, L. B. (1958).—The relation between ovarian development and mating in *L. cuprina*. *Aust. J. Sci.* 20 : 239-40.

Bornemissza, G. F. (1957).—An analysis of arthropod succession in carrion and the effect of its decomposition on the soil fauna. *Aust. J. Zool.* 5 : 1-12.

Carne, P. B. (1957).—"Systematic Revision of the Australian Dynastinae." (C.S.I.R.O.: Melbourne.)

Carne, P. B., *and* Chinnick, L. J. (1957).—The pruinose scarab (*Sericesthis pruinosa* Dalman) and its control in turf. *Aust. J. Agric. Res.* 8 : 604-16.

Common, I. F. B. (1957).—The occurrence of *Epinotia lantana* (Busck) (Lepidoptera : Olethreutidae) in Australia. *Proc. Linn. Soc. N.S.W.* 82 : 230-2.

Common, I. F. B. (1958).—The Australian cutworms of the genus *Agrotis* (Lepidoptera : Noctuidae). *Aust. J. Zool.* 6 : 69-88.

Few, A. V., Fraser, M. J., *and* Gilby, A. R. (1957).—The intracellular catalase of *Micrococcus lysodeikticus*. *Biochem. Biophys. Acta* 24 : 306-14.

Few, A. V., Gilby, A. R., Ottewill, R. H., *and* Parreira, H. C. (1957).—Dodecylquinolinium bromide. *J. Chem. Soc.* 346 : 1712-13.

Foster, A. B., *and* Hackman, R. H. (1957).—Application of ethylenediaminetetra-acetic acid in the isolation of crustacean chitin. *Nature* 180 : 40-1.

Gay, F. J. (1958).—Termite attack on radiata pine timber. *Aust. For.* 21 : 86-91.

Gay, F. J., Greaves, T., Holdaway, F. G., *and* Wetherly, A. H. (1957).—The development and use of field testing techniques with termites in Australia. C.S.I.R.O. Aust. Bull. No. 280.

Gay, F. J., Harrow, K. M., *and* Wetherly, A. H. (1958).—Laboratory studies of termite resistance. III. A comparative study of the anti-termitic value of boric acid, zinc chloride, and "Tanalith U". C.S.I.R.O. Aust. Div. Ent. Tech. Pap. No. 4.

Gay, F. J., *and* Wetherly, A. H. (1958).—Laboratory studies of termite resistance. I. The anti-termitic value of some chlorinated naphthalenes and phenols. C.S.I.R.O. Aust. Div. Ent. Tech. Pap. No. 2.

Gay, F. J., *and* Wetherly, A. H. (1958).—Laboratory studies of termite resistance. II. The termite resistance of untreated and treated hardboards. C.S.I.R.O. Aust. Div. Ent. Tech. Pap. No. 3.

Gilby, A. R. (1957).—Studies of cuticular lipides of arthropods. II. The chemical composition of the wax from *Ceroplastes destructor*. *Arch. Biochem. Biophys.* 67 : 307-19.

Gilby, A. R. (1957).—Studies of cuticular lipides of arthropods. III. The chemical composition of the wax from *Boophilus microplus*. *Arch. Biochem. Biophys.* 67 : 307-19.

Gilby, A. R., *and* Alexander, A. E. (1957).—Surface techniques in the study of complex mixtures of organic compounds. Proc. 2nd Int. Congr. Surf. Activity 4 : 341-6.

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Gilby, A. R., *and* Alexander, A. E. (1957).—Studies of cuticular lipides of arthropods. I. The influence of biological factors on the composition of the wax from *Ceroplastes destructor*. *Arch. Biochem. Biophys.* 67 : 302-6.

Gilby, A. R., *and* Few, A. V. (1957).—Surface chemical studies on the protoplast membrane of *M. lysodeikticus*. Proc. 2nd Int. Congr. Surf. Activity 4: 262-70.

Gilby, A. R., *and* Few, A. V. (1957).—Reactivity of ionic detergents with *Micrococcus lysodeikticus*. *Nature* 179 : 422-3.

Gilmour, D., *and* Griffiths, M. (1957).—The action of 2,4-dinitrophenol on myosin. *Arch. Biochem. Biophys.* 72 : 302-15.

Grylls, N. E., *and* Rafferty, W. J. (1957).—A useful device for handling active insects. *J. Aust. Inst. Agric. Sci.* 23 : 150-1.

Kerr, R. W., Venables, D. G., Roulston, W. J., *and* Schnitzerling, H. J. (1957).—Specific DDT-resistance in house flies. *Nature* 180: 1132-3.

Key, K. H. L. (1957).—Kentromorphic phases in three species of Phasmatodea. *Aust. J. Zool.* 5 : 247-84.

Nicholson, A. J. (1957).—The self-adjustment of populations to change. Cold Spring Harbor Symposia, June, 1957, 22 : 153-73.

Nicholson, A. J. (1958).—Dynamics of insect populations. *Annu. Rev. Ent.* 3: 107-36.

Norris, K. R. (1957).—A method of marking *Calliphorides* (Diptera) during emergence from the puparium. *Nature* 180 : 1,002.

Norris, K. R. (1957).—Strategic dipping for control of the cattle tick, *Boophilus microplus* in south Queensland. *Aust. J. Agric. Res.* 8 : 768-87.

Paramonov, S. J. (1957).—A review of Australian Acroceridae (Diptera). *Aust. J. Zool.* 5 : 521-46.

Paramonov, S. J. (1957).—Notes on Australian Diptera (23). Notes on some Australian *Ameniini* (Tachinidae: Diptera). *Ann. Mag. Nat. Hist.* 10 : 52-62.

Paramonov, S. J. (1957).—Notes on Australian Diptera (24). Key to Australian *Eumerus* species (Syrphidae). *Ann. Mag. Nat. Hist.* 10 : 125-8.

Paramonov, S. J. (1957).—Notes on Australian Diptera (25). On some new Ortalids (Acalyptrata). *Ann. Mag. Nat. Hist.* 10 : 779-81.

Paramonov, S. J. (1958).—Lord Howe Island, a riddle of the Pacific. *Pacif. Sci.* 12 : 82-91.

Paramonov, S. J. (1958).—Review of Australian species of *Laphria* (Asilidae, Diptera) with the description of three new species from Lord Howe Island. *Pacif. Sci.* 12 : 92-105.

Paramonov, S. J. (1958).—A review of Australian Pyrgotidae (Diptera). *Aust. J. Zool.* 6 : 89-136.

Roulston, W. J., *and* Schuntner, C. A. (1958).—Depletion of gamma isomer from benzene hexachloride cattle dipping fluids. *Aust. J. Agric. Res.* 9 : 503-20.

Rudman, P., Da Costa, E. W. B., Gay, F. J., *and* Wetherly, A. H. (1958).—Relationship of tectoquinone to durability in *Tectona grandis*. *Nature* 181 : 721-2.

Snowball, G. J. (1957).—Ecological observations on the cattle tick, *Boophilus microplus* (Can.). *Aust. J. Agric. Res.* 8 : 394-413.

Stone, B. F. (1957).—Resistance to DDT in the cattle tick, *Boophilus microplus*. *Aust. J. Agric. Res.* 8 : 423-31.

Wallace, M. M. H. (1957).—Experiments on the treatment of pastures with DDT and BHC for the control of the red-legged earth mite, *Halotydeus destructor* (Acarina: Penthaleidae) with an appendix on tests with other insecticides. C.S.I.R.O. Aust. Div. Ent. Tech. Pap. No. 1.

Wallace, M. M. H. (1957).—Field evidence of density governing reaction in *Sminthurus viridis* (L.). *Nature* 180 : 388-90.

Webber, L. G. (1957).—Utilization and digestion of carbohydrates by the Australian sheep blowfly *Lucilia cuprina* (Wied). *Aust. J. Zool.* 5 : 164-72.

White, M. J. D., *and* Chinnick, L. J. (1957).—Cytogenetics of the grasshopper *Moraba scurra*. III. Distribution of the 15- and 17-chromosome races. *Aust. J. Zool.* 5 : 338-47.

Wilkinson, P. R. (1957).—The spelling of pastures in cattle tick control. *Aust. J. Agric. Res.* 8 : 414-22.

10. DIVISION OF FISHERIES AND OCEANOGRAPHY.

Chittleborough, R. G. (1958).—The breeding cycle of the female humpback whale *Megaptera nodosa* (Bonnaterre). *Aust. J. Mar. Freshw. Res.* 9 : 1-18.

Cowper, T. R. (1958).—New records of fishes from the south-eastern Australian continental slope. *Pap. Roy. Soc. Tasm.* 92 : 149.

Hamon, B. V. (1958).—The effect of pressure on the electrical conductivity of sea-water. *J. Mar. Res.* 16.

Jitts, H. R. (1958).—Productivity studies. Rapport technique de l'Expedition Equapac. Sect. Océan. Rap. Scient. Inst. Franc. Océanie No. 3. Noumea.

Jitts, H. R., *and* Rotschi, H. (1957).—Mesure par la methode au C^{14} de l'activité photosynthetique de quelques masses d'eau du Pacifique Sud-Ouest en relation de l'étude de la fertilité de ces mêmes eaux. U.N.E.S.C.O. International Conference on Radioisotopes in Scientic Research. Paris, September, 1957.

Nicholls, A. G. (1957).—The Tasmanian trout fishery. I. Sources of information and treatment of data. *Aust. J. Mar. Freshw. Res.* 8 : 451-75.

Nicholls, A. G. (1958).—The Tasmanian trout fishery. II. The fishery of the north-west region. *Aust. J. Mar. Freshw. Res.* 9 : 19-59.

Olsen, A. M. (1958).—New fish records and notes on some uncommon Tasmanian species. *Pap. Roy. Soc. Tasm.* 92 : 155-9.

Rochford, D. J. (1957).—The identification and nomenclature of the surface water masses in the Tasman Sea (data to the end of 1954). *Aust. J. Mar. Freshw. Res.* 8 : 369-413.

Rochford, D. J. (1958).—The use of water mass composition in the interpretation of eastern Australian coastal oceanographical data. U.N.E.S.C.O. Symposium on Physical Oceanography, 1958.

Thompson, J. M. (1957).—The food of Western Australian estuarine fish. Bull. W. Aust. Fish. Dep. No. 7.

Thompson, J. M. (1957).—The size at maturity and spawning times of some Western Australian estuarine fishes. Bull. W. Aust. Fish. Dep. No. 8.

Tranter, D. J. (1957).—Pearl culture in Australia. *Aust. J. Sci.* 19 : 230-2.

Tranter, D. J. (1958).—Reproduction in Australian pearl oysters, *Pinctada albina* (Lamarck). I. Primary gonad development. *Aust. J. Mar. Freshw. Res.* 9 : 135-43.

Tranter, D. J. (1958).—Reproduction in Australian pearl oysters, *Pinctada albina* (Lamarck). II. Gametogenesis. *Aust. J. Mar. Freshw. Res.* 9 : 144-58.

Wood, E. J. F. (1958).—The significance of marine microbiology. *Bact. Rev.* 22 (1) : 1-19.

11. Fodder Conservation Section.

Greenhill, W. L. (1957).—Moisture changes in baled hay left out in the field. *Pwr. Fmg. & Bett. Fmg. Dig.* 66 (12) : 21.

McClelland, J. H., *and* Spielrein, R. E. (1957).—An investigation of the ultimate bending strength of some common pasture plants. *J. Agric. Engng. Res.* 2 : 288.

Shepherd, W. (1958).—Relations between moisture content, strength and elongation of Australian flax canvases. *Text. J. Aust.* 32 : 1458.

Shepherd, W. (1958).—Experimental methods in haymaking trials. *Aust. J. Agric. Res.* 9 : 27.

12. Division of Food Preservation and Transport.

Bain, Joan M. (1958).—Morphological, anatomical, and physiological changes in the developing fruit of the Valencia orange, *Citrus sinensis* (L.) Osbeck. *Aust. J. Bot.* 6 : 1-24.

Bouton, P. E., Howard, A., *and* Lawrie, R. A.* (1957).—Studies on beef quality. VI. Effect on weight losses and eating quality of further pre-slaughter treatments. C.S.I.R.O. Aust. Div. Food. Pres. Tech. Pap. No. 6.

Briggs, G. E.,† Hope, A. B., *and* Pitman, M. G.† (1957).—Measurement of ionic fluxes in red beet tissue using radioisotopes. Int. Conf. Radioisotopes Sci. Res. Pap. U.N.E.S.C.O./N.S./R.I.C./181.

Briggs, G. E.,† Hope, A. B., *and* Pitman, M. G.† (1958).—Exchangeable ions in beet disks at low temperature. *J. Exp. Bot.* 9 : 128-41.

Briggs, G. E.,† *and* Robertson, R. N. (1957).—Apparent free space. *Annu. Rev. Pl. Physiol.* 8 : 11-30.

Brown, A. D. (1957).—Some general properties of a psychrophilic pseudomonad: the effects of temperature on some of these properties and the utilization of glucose by this organism and *Pseudomonas aeruginosa*. *J. Gen. Microbiol.* 17 : 640-8.

Brown, A. D., Coote, G. G.,‡ *and* Meaney, M. F. (1957).—A property of ox muscle affecting bacterial growth at 0°. *J. Appl. Bact.* 20 : 75-85.

Chandler, B. V., *and* Harper, K. A. (1958).—Anthocyanins in blackcurrant fruits. *Nature* 181 : 131-2.

Davis, E. G. (1957).—Internal corrosion of cans. *C.S.I.R.O. Food Pres. Quart.* 17: 64-7.

Evans, H. L. (1958).—Studies in canning processes. II. The effects of the variation with temperature on the thermal properties of foods. *Food Tech., Champaign* 12 : 276-80.

Glazer, A. N.,§ McKenzie, H. A., *and* Wake, R. G.§ (1957).—Liberation of tyrosine hydroxyl groups in urea solutions of bovine serum albumin and ovalbumin. *Nature* 180 : 1286-7.

Hatch, M. D., *and* Millerd, Adele§ (1957).—Respiration of the spadix from the aroid *Zantedeschia aethipica* Spreng. *Aust. J. Biol. Sci.* 10 : 310-19.

Hicks, E. W. (1958).—Evaluation of canning processes when g is less than 0.1. *Food Tech., Champaign* 12 : 116.

Honda, S. I., Robertson, R. N., *and* Gregory, Jeanette M. (1958).—Studies in the metabolism of plant cells. XII. Ionic effects on oxidation of reduced diphosphopyridine nucleotide and cytochrome *c* by plant mitochondria. *Aust. J. Biol. Sci.* 11 : 1-15.

Howard, A., *and* Lawrie, R. A.* (1957).—Studies on beef quality. IV. The effect of blast-freezing of hot beef quarters and pre-slaughter injection of magnesium sulphate. C.S.I.R.O. Aust. Div. Food Pres. Tech. Pap. No. 3.

Howard, A., *and* Lawrie, R. A.* (1957).—Studies on beef quality. V. Further observations on biochemical and physiological responses to pre-slaughter treatments. C.S.I.R.O. Aust. Div. Food Pres. Tech. Pap. No. 4.

Lynch, L. J., *and* Mitchell, R. S. (1957).—Apparatus for testing vacuum in containers. Aust. Pat. 209624.

McBean, D., *and* Johnson, A. A. (1957).—Control of spoilage in high moisture prunes. *C.S.I.R.O. Food Pres. Quart.* 17 : 48-51.

McKee, H. S. (1957).—Some practices of the Pacific Island peoples in handling and storing foodstuffs. *Aust. J. Sci.* 20 : 69-71.

McKenzie, H. A. (1958).—Polarographic methods with special reference to trace analysis. *Rev. Pure Appl. Chem.* 8 : 53-84.

Marshall, Betty J., *and* Scott, W. J. (1958).—Water relations of *Vibrio metchnikovi* at 30° C. *Aust. J. Biol. Sci.* 11 : 171-6.

Moorjani, M. N.† (1957).—Glycogen and hydrogen ion concentrations in sheep muscle. *C.S.I.R.O. Food Pres. Quart.* 17 : 25.

Prater, A. R., *and* Elliott, A. G. L.‡ (1957).—Storage tests on air-dried mutton mince. C.S.I.R.O. Aust. Div. Food Pres. Tech. Pap. No. 5.

Robertson, R. N. (1957).—Electrolytes in plant tissue. *Endeavour* 16 : 193-8.

Rowan, K. S. (1957).—Phosphorylated compounds in plants. I. Adenosine and uridine 5′-phosphates in pea seedlings. *J. Exp. Bot.* 8 : 256-71.

Rowan, K. S., *and* Turner, Donella H. (1957).—Physiology of pea fruits. V. Phosphate compounds in the developing seed. *Aust. J. Biol. Sci.* 10 : 414-25.

Scott, W. J.—Method and means for the dried storage of microorganisms. Aust. Pat. 212235.

Shenstone, F. S., *and* Vickery, J. R. (1958).—Studies in the preservation of shell eggs. VIII. The effects of the treatment of shell eggs with oil. C.S.I.R.O. Div. Food Pres. Tech. Pap. No. 7.

Smith, M. B., *and* Alexander, A. A.§ (1957).—Solubilization in soap micelles. Proc. 2nd Int. Congr. Surface Activity 1 : 349-56.

Turner, Donella, H., *and* Turner, J. F. (1957).—Physiology of pea fruits. III. Changes in starch and starch phosphorylase in the developing seed. *Aust. J. Biol. Sci.* 10 : 302-9.

Turner, J. F. (1957).—The biosynthesis of sucrose. *Biochem. J.* 67 : 450-6.

Turner, J. F., *and* Mapson, L. W.* (1958).—Aerobic inhibition of glycolysis. *Nature* 181 : 270.

Turner, J. F., Turner, Donella H., *and* Lee, J. B. (1957).—Physiology of pea fruits. IV. Changes in sugars in the developing seed. *Aust. J. Biol. Sci.* 10 : 407-13.

13. Division of Forest Products.

Beesley, J. (1958).—Deterioration of timber in service and storage. *Aust. Timber J.* 24 (3) : 32, 34, 37-8, 95.

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§ University of Sydney.

Bland, D. E. (1958).—Qualitative paper chromatographic analysis of methanol lignin from *Eucalyptus regnans*. *Holzforschung* 12 : 19-23.

Bland, D. E. (1958).—Chemistry of reaction wood. Part I. Lignins of *Eucalyptus goniocalyx* and *Pinus radiata*. *Holzforschung* 12 : 36-43.

Chattaway, M. Margaret (1958).—Bud development and lignotuber formation in eucalypts. *Aust. J. Bot.* 6 : 103-14.

Clarke, S. A. (1957).—Boards and the utilization of tropical forests. *Unasylva* 11 : 116-17.

Da Costa, E. W. B., *and* Rudman, P. (1958).—Causes of natural durability in timber. I. Role of toxic extractives in the resistance of tallowwood (*Eucalyptus microcorys* F. Muell.) to decay. *Aust. J. Biol. Sci.* 11 : 45-7.

Dadswell, H. E. (1957).—Tree growth characteristics and their influence on wood structure and properties. 7th Brit. Commonw. For. Conf. 1957.

Dadswell, H. E. (1958).—Wood structure variations occurring during three growth and their influence on properties. *J. Inst. Wood Sci.* (1) : 11-33.

Elliot, C. S. (1958).—Plywood investigations in the Division of Forest Products. *Aust. Timber J.* 24 (4): 112-13.

Gottstein, J. W. (1958).—Some features of cross feed and end feed splicers. *Aust. Timber J.* 24 (4) : 124-5.

Gottstein, J. W. (1958).—Comparison of air and accelerated drying methods for veneers. *Aust. Timber J.* 24 (4): 114-15.

Grossman, P. U. A. (1958).—Simple instrument for the periodic application of controlled bi-axial strains. *J. Sci. Instrum.* 35 : 131-4.

Higgins, H. G. (1957).—Use of potassium chloride disks in the infra-red examination of fibrous cellulose and other solid materials. *Aust. J. Chem.* 10 : 496-501.

Higgins, H. G. (1958).—Degradation of cellulose in air at 250° C. as shown by infra-red spectroscopic examination. *J. Polym. Sci.* 28 : 645-8.

Higgins, H. G., *and* McKenzie, A. W. (1958).—Structure and properties of paper. X. Periodic acid oxidation of cellulose fibres and its influence on paper properties. *Aust. J. Appl. Sci.* 9 : 167-82.

Higgins, H. G., McKenzie, A. W., *and* Harrington, K. J. (1958).—Structure and properties of paper. VII. Study of the mechanisms of beating and interfibre bonding by means of esterification. *Tappi* 41 : 193-204.

Jones, D. S. (1957).—Slower saw speeds may mean savings. *Aust. Timber J.* 23 (5): 19, 25.

Kelsey, Kathleen E., *and* Kingston, R. S. T. (1957).—Effect of specimen shape on the shrinkage of wood. *For. Prod. J.* 7 : 234-5.

Kloot, N. H., *and* Schuster, K. B. (1958).—Effect of cross-grain on the bending properties of jarrah scantlings. *Aust. J. Appl. Sci.* 9 : 9-17.

McKenzie, A. W. (1958).—Structure and properties of paper. VIII. Influence of fibre swelling on the beating process. *Appita* 11 : 84-9.

Pearson, R. G. (1958).—Design notes for plywood and timber in concrete formwork. *In* " Plywood for Concrete Formwork ": pp. 11-20. (Australian Plywood Board: Brisbane.)

Rudman, P., *and* Da Costa, E. W. B. (1958).—Causes of natural durability in timber. II. The role of toxic extractives in the resistance of silvertop ash (*Eucalyptus sieberiana* F. Muell.) to decay. C.S.I.R.O. Aust. Div. For. Prod. Technol. Pap. No. 1.

Rudman, P., Da Costa, E. W. B., Gay, F. J., *and* Wetherly, A. H. (1958).—Relationship of tectoquinone to durability in *Tectona grandis*. *Nature* 181 : 721-2.

Schwerin, Gerda (1958).—Chemistry of reaction wood. 2. Polysaccharides of *Eucalyptus goniocalyx* and *Pinus radiata*. *Holzforschung* 12 : 43-8.

Stewart, C. M., Watson, A. J., *and* Dadswell, H. E. (1958).—Process of fibre separation. Pt. I. *Appita* 11 : 112-23.

Tamblyn, N. (1957).—Importance of preservative treatments in hardwood utilization. Brit. Commonw. For. Conf., 7th, 1957. pp. 15.

Tamblyn, N., *and* Da Costa, E. W. B. (1958).—Simple technique for producing fruit bodies of wood-destroying basidiomycetes. *Nature* 181 : 578-9.

Turnbull, R. F. (1957).—Radiata pine utilization in South Australia. *Builder, Adelaide* 34 (29) : 8-9, 11, 13.

Walters, N. E. M. (1958).—*Poria healeyi* sp. nov. The casual fungus of yellow straw rot in jarrah (*Eucalyptus marginata* Sm.). *Trans. Brit. Mycol. Soc.* 41 : 95-8.

Wardrop, A. B. (1957).—Organization and properties of the outer layer of the secondary wall in conifer tracheids. *Holzforschung* 11 : 102-10.

Wardrop, A. B., *and* Cronshaw, J. (1958).—Changes in cell wall organization resulting from surface growth in parenchyma of oat coleoptiles. *Aust. J. Bot.* 6 : 89-95.

Wardrop, A. B., *and* Davies, G. W. (1958).—Some anatomical factors relating to the penetration of water into xylem of gymnosperms. *Aust. J. Bot.* 6 : 96-102.

Watson, A. J., *and* Dadswell, H. E. (1957).—Papermaking properties of compression wood from *Pinus radiata*. *Appita* 11 : 56-69.

Watson, A. J., Dadswell, H. E., *and* Stewart, C. M. (1958).—Process of fibre separation. III. Cold soda pulps from *Eucalyptus regnans*. *Appita* 11 : 145-55.

Watson, A. J., *and* Stamp, Clare (1957).—Influence of different operating procedures on the permanganate number determination. *Appita* 11 : 4-11.

14. Division of Industrial Chemistry.

Barker, J. A. (1957).—Cluster integrals and statistical mechanics of solutions. *Proc. Roy. Soc.* A 241 : 547.

Barnes, C. S. (1957).—Methylsteroids. IV. Wolff-Kishner reductions of diketones derived from lanosterol. *Aust. J. Chem.* 10 : 370.

Barnes, C. S. (1958).—The properties and structures of the 1,8-terpins and some related compounds. *Aust. J. Chem.* 11 : 134.

Barnes, C. S., *and* Palmer, A. (1957).—Methylsteroids. III. Reduction of ketones derived from lanosterol. *Aust. J. Chem.* 10 : 334.

Bayston, J., King, N. Kelso, *and* Winfield, M. E. (1957).—Hydrogenation catalysis by complex ions of cobalt. *Advan. Catalys.* 9 : 312.

Bear, Miss I. J. (1958).—Lithium: its extraction from Western Australian spodumene ore. *Chem. Engng. Min. Rev.* 50 : 40.

Beecham, A. F. (1957).—Tosyl-α-amino acids. Part I. Degradation of the acid chlorides and azides by aqueous alkali. *J. Amer. Chem. Soc.* 79 : 3257.

Beecham, A. F. (1957).—Tosyl-α-amino acids. Part II. The use of the acid chlorides for peptide synthesis in the presence of aqueous alkali. *J. Amer. Chem. Soc.* 79 : 3262.

Billington, C. (1957).—A discussion of series valves for small D.C. voltage stabilizers. *Electron. Engng.* 29 : 377.

Billington, C., *and* Chakanovskis, E. (1957).—A voltage stabilizer principle. *Electron. Engng.* 29 : 374.

Billington, C., *and* Chakanovskis, E. (1958).—A voltage stabilizer principle. *Electron. Engng.* 30 : 210.

Blackwood, J. D., *and* McGrory, F. (1958).—The carbon steam reaction at high pressure. *Aust. J. Chem.* 11 : 16.

Brown, I., *and* Fock, W. (1957).—Heats of mixing. III. Acetone and alcohol solutions. *Aust. J. Chem.* 10 : 417.

Brown, I., *and* Smith, F. (1957).—Liquid-vapour equilibria. VIII. The systems acetone + benzene and acetone + carbon tetrachloride at 45° C. *Aust. J. Chem.* 10 : 422.

Bruère, G.—Improvements in and relating to concrete mortar or the like. Argentinian Pat. 111549, Belgian Pat. 560346.

Bruère, G. M., *and* McGowan, J. K. (1958).—Synthetic polyelectrolytes as concrete admixtures. *Aust. J. Appl. Sci.* 9 : 127.

Cathro, K. J., *and* Walkley, A. (1958).—The simultaneous determination of copper and iron. *J. Polym. Sci.* 27 : 36.

Cathro, K. J., *and* Walkley, A. (1958).—The polarographic determination of copper and iron and its application in the hydrometallurgy of copper. *Aust. J. Appl. Sci.* 9 : 105.

Coogan, C. K. (1957).—The measurement of the optical properties of zinc sulphide. *Proc. Phys. Soc. Lond.* **B 70: 845.**

Coogan, C. K. (1958).—A simple method of monitoring ultra-violet light. *J. Sci. Instrum.* 35 : 64.

Cope, J. O. (1958).—A magnetically operated needle valve. *Rev. Sci. Instrum.* 29 : 232.

Cowley, J. M., *and* Moodie, A. F. (1957).—The scattering of electrons by atoms and crystals. I. A new theoretical approach. *Acta. Cryst., Camb.* 10 : 609.

Cowley, J. M. *and* Moodie, A. F. (1957).—ISAAC—an image-seeking computer using contoured pattern maps. *Acta Cryst., Camb.* 10 : 740.

Cowley, J. M., *and* Moodie, A. F. (1957).—Possibilities for the direct observation of crystal structures. *Acta Cryst., Camb.* 10 : 752.

Cowley, J. M., *and* Moodie, A. F. (1957).—A new approach to electron diffraction theory, with application to structure analysis. *Acta Cryst., Camb.* 10 : 859.

Cowley, J. M., *and* Moodie, A. F. (1958).—A new formulation of scalar diffraction theory for restricted aperture. *Proc. Phys. Soc. Lond.* B 71: 533.

Cowley, J. M., *and* Rees, A. L. G. (1958).—Fourier methods in structure analysis by electron diffraction. *Rep. Progr. Phys.* 21 : 165.

Cox, R. W., *and* Williamson, W. O. (1958).—The differential shrinkage of clays and bodies caused by particle-orientation and its significance in testing procedure. *Trans. Brit. Ceram. Soc.* 57 : 85.

Croft, R. C. (1958).—New molecular compounds of graphite. Proc. Third Carbon Conf., Buffalo, New York.

Crow, W. D. (1958).—Quinolizidine alkaloids. *In* "Current Trends in Heterocyclic Chemistry". p. 111. (Butterworth : London.)

Crow, W. D., *and* Greet, Miss Y. M. (1957).—A universal composition/anti-composition calculator for use in organic chemical analyses. *Chem. & Ind.* 1957 : 1618.

Culvenor, C. C. J. (1958).—Some alkaloids of Australian *Crotalaria* species. *In* "Current Trends in Heterocyclic Chemistry". p. 103. (Butterworth : London.)

Culvenor, C. C. J., *and* Smith, L. W. (1957).—The alkaloids of *Crotalaria retusa* L. *Aust. J. Chem.* 10 : 464.

Culvenor, C. C. J., *and* Smith, L. W. (1957).—The alkaloids of *Crotalaria spectabilis* Roth. *Aust J. Chem.* 10 : 474.

Dalton, L. K., *and* Lamberton, J. A. (1958).—Studies of the optically active compounds of the Anacardiaceae exudates. Part I. The long chain alicyclic ketoalcohol of Tigaso oil. *Aust. J. Chem.* 11 : 46.

Dalton, L. K. *and* Lamberton, J. A. (1958).—Studies of the optically active compounds of Anacardiaceae exudates. Part II. The action of alkali on the long-chain alicyclic ketoalcohol of Tigaso oil. *Aust. J. Chem.* 11 : 64.

Davey, P. T., *and* Scott, T. R. (1957).—Preparation of maghemite by electrolysis. *Nature* 179 : 1363.

David, H. G., and Hamann, S. D. (1957).—The gas imperfections of hydrocarbons. Proc. Conf. on Thermodynamic and Transport properties of Fluids, Lond. p. 74.

David, H. G., *and* Hamann, S. D. (1958).—Sulfur: a possible metallic form. *J. Chem. Phys.* 28 : 1006.

Davies, D. A.—Method and apparatus for machining cylindrical bars or holes. Ital. Pat. 573684.

Davis, C. E. S. (1957).—Studies in cement-aggregate reaction. XXV. Comparison of the expansion of mortar and concrete. *Aust. J. Appl. Sci.* 8 : 222.

Davis, C. E. S. (1958).—Studies in cement-aggregate reaction. XXVI. Comparison of the effect of soda and potash on expansion. *Aust. J. Appl. Sci.* 9 : 52.

Dowell, W. C. T., *and* Farrant, J. L. (1957).—Electron diffraction at a circular obstacle. Proc. First Regional Conf. on Electron Microscopy in Asia and Oceania, Tokyo, 1956, p. 326.

Dowell, W. C. T., Farrant, J. L., *and* Rees A. L. G. (1957).—Electron interference fringes from superimposed lamellar crystals. Proc. First Regional Conf. on Electron Microscopy in Asia and Oceania, Tokyo, 1956, p. 320.

Evans, L. F., *and* Ewers, W. E.—Improved process for the recovery of wool wax from wool scour liquor froths. U.S.A. Pat. 2820803.

Ewald, A. H., Hamann, S. D., *and* Stutchbury, J. E. (1957).—The effect of pressure on some free radical reactions of 1 : 2-dichlorethylene. *Trans. Faraday Soc.* 53 : 991.

Ewald, A. H., *and* Lim, S. C. (1957).—Voltammetry at high pressure. *J. Phys. Chem.* 61 : 1443.

Farrant, J. L., *and* Powell, S. E. (1957).—A new ultra-mictrotome. Proc. First Regional Conf. on Electron Microscopy in Asia and Oceania, Tokyo, 1956, p. 147.

Garten, V. A., *and* Weiss, D. E. (1957).—A new interpretation of the acidic and basic structure in carbon. Part II. The chromene-carbonium ion couple in carbon. *Aust. J. Chem.* 10 : 309.

Garten, V. A., *and* Weiss, D. E. (1958).—Functional groups in activated carbon and carbon black with ion- and electron-exchange properties. Proc. Third Carbon Conf., Buffalo, New York.

Garten, V. A., Weiss, D. E., *and* Willis, J. B. (1957).—A new interpretation of the acidic and basic structures in carbons. Part I. Lactone groups of the ordinary and fluorescein types in carbons. *Aust. J. Chem.* 10 : 295.

Grant, K. (1957).—The slagging of refractories by brown coal ash. *Aust. J. Appl. Sci.* 8 : 323.

Grant, K., *and* Williamson, W. O. (1957).—The loss in strength of silica bricks reheated in hydrogen or carbon monoxide. *Trans. Brit. Ceram. Soc.* 56 : 277.

Ham, N. S., *and* Walsh, A. (1958).—Microwave-powered Raman sources. *Spectrochim. Acta* 12 : 88.

Hamann, S. D. (1957).—Quantal factors in the Joule-Thomson cooling of hydrogen and deuterium. *Aust. J. Chem.* 10 : 373.

Hamann, S. D. (1958).—The chemical effects of pressure. Part IV. The role of viscosity in bimolecular reactions at high pressure. *Trans. Faraday Soc.* 54 : 507.

Hatt, H. H., *and* Lamberton, J. A.—Modified sugar cane waxes for use in polishes and the production of said waxes. U.K. Pat. 773590.

Hurley, A. C. (1958).—The role of atomic valence states in molecular energy calculation. *J. Chem. Phys.* 28 : 532.

Hurzeler, H., Inghram, M. G., *and* Morrison, J. D. (1958).—Photon impact studies of molecules using a mass spectrometer. *J. Chem. Phys.* 28 : 76.

Ingles, O. G. (1958).—Design and operation of a high pressure mercury porosimeter. *Aust. J. Appl. Sci.* 9 : 120.

King, N. K., *and* Winfield, M. E. (1958).—Reduction of water in hydrogen by a complex cyanide of cobalt. *J. Amer. Chem. Soc.* 80 : 2060.

Koch, D. F. A., *and* Walkley, A. (1957).—The effect of particle size distribution on the course of a heterogenous reaction. Proc. Third Int. Meeting on the Reactivity of Solids, Madrid, 1956, p. 453.

Lamberton, J. A. (1958).—Studies of the optically active compounds of Anacardiaceae exudates. Part III. The long-chain alicyclic ketoalcohols from the exudate of *Campnosperma auriculata* Hook F. *Aust. J. Chem.* 11 : 73.

Linton, M., *and* Sutherland, K. L. (1957).—Dynamic surface forces, drop circulation, and liquid-liquid mass transfer. Proc. 2nd Int. Congr. of Surface Activity 1 : 494.

Linton, M., *and* Sutherland, K. L. (1958).—The solution of oxygen through a monolayer. *Aust. J. Appl. Sci.* 9 : 18.

McTaggart, F. K.—Titanium sulphide base lubricants especially suitable for high temperature conditions and methods of producing them. Aust. Pat. 205,568.

McTaggart, F. K., *and* Bear, Joy (1958).—Phototropic effects in oxides. II. White oxides in general. *J. Appl. Chem.* 8 : 72.

Martin, R. J. L. (1957).—Electrostatic, polar, and steric factors in the acid hydrolysis of the dipeptide. *Aust. J. Chem.* 10 : 256.

Martin, R. J. L. (1957).—The kinetics of the acid hydrolysis of some dipeptides in acetic acid. *Aust. J. Chem.* 10 : 268.

Mathieson, A. McL. (1958).—Mg-vermiculite: a refinement and re-examination of the crystal structure of the 14.36 Å phase. *Amer. Min.* 43 : 216.

Mills, J. C. (1957).—Adjustable apertures for electron diffraction cameras. *J. Sci. Instrum.* 34 : 460.

Morrison, J. D. (1957).—Application of the mass spectrometer to the study of the upper energy states of molecules. *J. Appl. Phys.* 28 : 1409.

Newnham, I. E.—Method of producing hafnium free "crystal-bar" zirconium from a crude source of zirconium. Aust. Pat. 207,410.

Newnham, I. E.—A process for removing hafnium from zirconium or its compounds. Aust. Pat. 167,210, U.K. Pat. 778,192.

Newnham, I. E.—A process for removing hafnium from zirconium or its compounds. Aust. Pat. 167,211, U.K. Pat. 780,477.

Newnham, I. E. (1957).—Zirconium for nuclear reactors. *Research* 10 : 424.

Newnham, I. E. (1957).—The separation of zirconium and hafnium by differential reduction of their tetrachlorides. *J. Amer. Chem. Soc.* 79 : 5415.

Newnham, I. E. (1958).—The metallurgy of beryllium. *Research* 11 : 185.

Price, J. R. (1958).—A novel type of naturally occurring quaternary base. *In* "Current Trends in Heterocyclic Chemistry". p. 92. (Butterworth: London.)

Redcliffe, A. H., *and* Hatt, H. H.—An improved process for refining sugar cane wax with solvents. Aust. Pat. 211,617.

Rees, A. L. G. (1957).—Current developments in scientific organization and research in Australia. *J. Roy. Inst. Chem.* 81 : 501.

Rees, A. L. G. (1957).—Symbolism for defect solids. Proc. Third Int. Meeting on the Reactivity of Solids, Madrid, 1956, p. 587.

Riviere, J. C. (1957).—Contact potential difference measurements by the Kelvin method. *Proc. Phys. Soc. Lond.* B 17 : 676.

Scott, T. R. (1958).—The extraction and recovery of uranium from Australian ores. Proc. Rare Metals Symposium, Bombay, India.

Skewes, H. R.—A process for the production of ductile electrolytic copper. Belgian Congo Pat. 5324, Southern Rhodesian Pat. 281/1957, Northern Rhodesian Pat. SR 586.

Stanton, H. E., *and* Morrison, J. D. (1958).—Fragmentation of methane by electron impact and the latent heat of sublimation of carbon. *J. Chem. Phys.* 28 : 9.

Strauss, W. (1957).—Ionization of picric acid in methanol to 3000 atm. *Aust. J. Chem.* 10 : 277.

Strauss, W. (1957).—Nucleophilic substitution reactions at high pressure. *Aust. J. Chem.* 10 : 381.

Vivian, H. E. (1958).—Industries dependent on the chemical profession: the cement industry in Australia. *Proc. Roy. Aust. Chem. Inst.* 25 : 16.

Wadsley, A. D. (1957).—Partial order in the non-stoichiometric phase $Ti_{2+x}S_4(0.2<x<1)$. *Acta Cryst., Camb.* 10 : 715.

Walker, G. F. (1957).—On the differentiation of vermiculites and smectites in clays. *Clay Min. Bull.* 3 : 154.

Walkley, A. (1957).—Research on primary cells. *Direct Current* 3 : 141.

Walsh, A.—Multiple monochromator. Canad. Pat. 544774, Swedish Pat. 159472.

Walsh, A.—Multiple monochromator. Dutch Pat. 87576.

Warren, I. H. (1957).—Laboratory pressure leaching technique. *Aust. J. Appl. Sci.* 8 : 317.

Warren, I. H. (1958).—A study of the acid pressure leaching of chalcopyrite, chalcocite, and covellite. *Aust. J. Appl. Sci.* 9 : 36.

Weiss, D.E., *and* Swinton, E. A.—Improved method and means for extracting an adsorbable solute from a suspension of finely divided solids in a solution. Norwegian Pat. 89543, U.K. Pat. 775415, Indian Pat. 55618.

Weiss, D. E., *and* Swinton, E. A.—Improved method of and apparatus for obtaining continuous counter-current contact between solid particles and a liquid. Canad. Pat. 541483, Indian Pat. 56004, U.K. Pat. 770110.

Weiss, D. E., *and* Swinton, E. A.—Method and means for continuously extracting an adsorbable solute from a clear solution or from a suspension of finely divided solids in a liquid. U.K. Pat. 780406, Indian Pat. 56175.

Williamson, W. O. (1957).—Industries dependent on the chemical profession: the ceramic industry in Australia. *Proc. Roy. Aust. Chem. Inst.* 24 : 422.

Williamson, W. O. (1957).—Some impressions of the Indian ceramic industry. *Clay Prod. J.* 24 : 21.

Williamson, W. O. (1958).—Ceramic science and technology in the U.S.A. Part I. Experience in the University of California and at a Gordon Conference. *Clay Prod. J.* 25 : 13.

Williamson, W. O. (1958).—Ceramic science and technology in the U.S.A. II. Magnetic ceramic materials —the ferrites. *Clay Prod. J.* 25 : 25.

Williamson, W. O. (1958).—Particle orientation in clays and whiteware and its relation to forming processes. *In* "Ceramic Fabrication Processes". Chapter II. (John Wiley and Son Inc.: New York.)

Williamson, W. O. (1958).—Ceramic research in Australia. Parts I. and II. *Ceramics* 9 : 27.

Willis, J. B. (1957).—The present state of Raman spectroscopy in chemistry. *Proc. Roy. Aust. Chem. Inst.* 24 : 549.

Willis, J. B. (1958).—Vibrational spectroscopy and its application in structural inorganic chemistry. *Rev. Pure Appl. Chem.* 8 : 101.

15. IRRIGATION RESEARCH STATIONS.

Antcliff, A. J. (1957).—2,3,4-Trichlorophenoxyacetic acid as a spray to replace cincturing of currants. *J. Aust. Inst. Agric. Sci.* 23 : 242-3.

Antcliff, A. J., Webster, W. J., and May, P. (1957).—Recovery of sultana vines after spring damage. *Aust. J. Agric. Res.* 8 : 352-8.

Antcliff, A. J., Webster, W. J., *and* May, P. 1958.—Studies on the sultana vine. VI. The morphology of the cane and its fruitfulness. *Aust. J. Agric. Res.* 9 : 328-38.

Giles, J. E. (1958).—Effect of "Krilium" as a soil improver for glasshouse tomatoes. *J. Aust. Inst. Agric. Sci.* 24 : 160-3.

Giles, J. E., *and* Hutton, E. M. (1958).—Combining resistance to the rootknot nematode *Meloidogyne javanica* (Treub) Chitwood, and fusarium wilt in hybrid tomatoes. *Aust. J. Agric. Res.* 9 : 182-92.

Groenewegen, H. (1957).—A salinity survey of the Mirrool Irrigation Area. *J. Aust. Inst. Agric. Sci.* 23 : 323-8.

Martin, R. J. L., *and* Stott, G. L. (1957).—The physical factors involved in drying of sultana grapes. *Aust. J. Agric. Res.* 8 : 444-59.

May, P., *and* Webster, W. J. (1958).—The bud strain of *Eriophyes vitis* (Pgst.) in Australia. *J. Aust. Inst. Agric. Sci.* 24 : 163-6.

Sauer, M. R. (1958).—Boron content of sultana vines in the Mildura area. *Aust. J. Agric. Res.* 9 : 123-8.

Sauer, M. R. (1958).—Development of eggs before the final moult in *Pratylenchus*. *Nature* 181 : 129.

Sauer, M. R. (1958).—*Hopolaimus gracilidens, Radopholus inaequalis,* and *Radopholus neosimilis,* three new tylenchs native to Victoria, Australia. *Nematologica* 3 : 97-107.

Talsma, T., *and* Flint, S. E. (1958).—Some factors determining the hydraulic conductivity of subsoils with special reference to tile drainage problems. *Soil Sci.* 85 : 198-206.

Talsma, T., *and* Haskew, H. C. (1958).—Investigations of water table response to tile drains in comparison with theory. *Trans. Amer. Geophys. Un.* 39.

16. DIVISION OF LAND RESEARCH AND REGIONAL SURVEY.

Anon. (1958).—Kimberley Research Station. A progress report. *J. Agric. W. Aust.* 7 : 238-57.

Christian, C. S. (1957).—The concept of land units and land systems. Paper presented to 9th Pacif. Sci. Congr., Bangkok.

Christian, C. S., Jennings, J. N.,* *and* Twidale, C. R. (1957).—Geomorphology. *In* "Arid Zone Research Handbook". Chap. 5. pp. 51-65. (U.N.E.S.C.O.: Paris.)

Christian, C. S., Norman, M. J. T., *and* Arndt, W. (1957). —Some investigations related to livestock production in the Northern Territory of Australia. Paper presented to 9th Pacif. Sci. Congr., Bangkok.

Christian, C. S., *and* Phillis, E. (1957).—A progress report on tropical crop experiments in northern Australia. Paper presented to Pan Indian Ocean Sci. Ass., 3rd Sci. Congr., Madagascar.

Ford, N., *and* Ising, E. H.,† (1958).—*Acacia calciocola,* a new species of importance to the ecology of the Australian arid zone. *Trans. Roy. Soc. S. Aust.* 81 : 153-60.

Langfield, E. C. B. (1957).—Time of harvest in relation to grain breaking on milling in rice. *J. Aust. Inst. Agric. Sci.* 23 : 340-1.

Norman, M. J. T. (1957).—Weight responses to tick control and phosphate supplementation in beef cattle at Katherine, N.T. *J. Aust. Inst. Agric. Sci.* 23 : 344-5.

Slatyer, R. O. (1957).—The influence of progressive increases in total soil moisture stress on transpiration, growth, and internal water relationships of plants. *Aust. J. Biol. Sci.* 10 : 320-36.

Slatyer, R. O. (1957).—The significance of the permanent wilting percentage in studies of plant and soil water relations. *Bot. Rev.* 23 : 585-636.

17. MATHEMATICAL INSTRUMENTS SECTION.

Allen, M. W. (1957).—A.D.A.—a transistor decimal digital differential analyser. *J. Instn. Engrs. Aust.* 29 : 255.

Allen, M. W., *and* Speedy, C.—Apparatus for carrying out algebraic operations on binary numbers. U.K. Pat. 767620, U.S.A. Pat. 2812135.

Bonython, C. W., *and* Myers, D. M. (1958).—The theory of recovering salt from sea water by polar evaporation. *J. Appl. Chem.* 8 : 207.

18. DIVISION OF MATHEMATICAL STATISTICS.

Brown, A. D.,‡ Coote, C. G., *and* Meaney, M. F.‡ (1957). —A property of ox muscle affecting bacterial growth at 0°. *J. Appl. Bact.* 20 : 75-85.

Coaldrake, J. E.,§ *and* Haydock, K. P. (1958).—Soil phosphate and vegetal pattern in some natural communities of south-eastern Queensland. *Ecology* 39 : 1-5.

Coote, G. G., *and* Cornish, E. A. (1958).—Correlation of monthly rainfall with position and altitude of observing stations in South Australia. C.S.I.R.O. Aust. Div. Math. Statist. Tech. Pap. No. 4.

Hill, G. W., *and* Pearcy, T.‖ (1957).—Programme design for the C.S.I.R.O. Mark I Computer. IV. Automatic programming by simple compiler techniques. *Aust. J. Phys.* 10 : 137-61.

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James, A. T. (1957).—The relationship algebra of an experimental design. *Ann. Math. Statist.* 28 : 993-1002.

Lyne, A. G.,* *and* Verhagen, A. M. W. (1957).—Growth of the marsupial *Trichosurus vulpecula* and a comparison with some higher mammals. *Growth* 21 : 167-95.

Prater, A. R.,† *and* Elliott, A. G. L. (1957).—Storage tests on air-dried mutton mince. C.S.I.R.O. Aust. Div. Food Pres. Tech. Pap. No. 5.

Stenhouse, N. S., *and* Cornish, E. A. (1958).—Interstation correlations of monthly rainfall in South Australia. C.S.I.R.O. Aust. Div. Math. Statist. Tech. Pap. No. 5.

Weiler, H. (1957).—The errors due to non-normality in mean charts using runs. *Aust. J. Appl. Sci.* 8 : 181-8.

Wilkinson, G. N. (1957).—The analysis of covariance with incomplete data. *Biometrics* 13 : 363-72.

Wilkinson, G. N. (1958).—Estimation of missing values for the analysis of incomplete data. *Biometrics* 14 : 257-86.

19. DIVISION OF METEOROLOGICAL PHYSICS.

Ball, F. K. (1957).—The katabatic winds of Adelie Land and King George V. Land. *Tellus* 9 : 201-8.

Ball, F. K. (1958).—Some observations of bent plumes. *Quart. J. R. Met. Soc.* 84 : 61-5.

Berson, A. F. A. (1956).—Statistical aspects of tropical cyclone steering. Tropical Cyclone Symposium, Brisbane, Pap. No. 19.

Berson, A. F. A. (1958).—Some measurements on undercutting cold air. *Quart. J. R. Met. Soc.* 84 : 1-16.

Clarke, R. H. (1958).—Some observations on spring rainfall at Melbourne. *Aust. Met. Mag.* (20) : 39-60.

Deacon, E. L. (1957).—What is our climate doing? *Land Facts* 4 : 1.

Deacon, E. L. (1957).—Wind profiles and the shearing stress—an anomaly resolved. *Quart. J. R. Met. Soc.* 83 : 537-40.

Deacon, E. L. (1957).—Eddy flux measurements over the sea. Proc. Symp. on " Water Balance ", Oceanogr. Ass. of Int. Un. Geol. Geophys.

Deacon, E. L., Priestley, C. H. B., *and* Swinbank, W. C. (1958).—Evaporation and the water balance. U.N.E.S.C.O. Reviews of Research, Climatology.

Dyer, A. J., *and* Taylor, R. J. (1957).—An instrument for measuring evaporation from natural surfaces. *Nature* 181 : 408-9.

Swinbank, W. C. (1957).—The measurement of evaporation from the oceans. Proc. Symp. on " Water Balance ", Oceanogr. Ass. of Int. Un. Geol. Geophys.

Taylor, R. J. (1958).—A linear unidirectional anemometer of rapid response. *J. Sci. Instrum.* 35 : 47-52.

Taylor, R. J. (1958).—Thermal structures in the lowest layers of the atmosphere. *Aust. J. Phys.* 11 : 168-76.

Taylor, R. J., *and* Dyer, A. J. (1957).—The direct measurement of natural evaporation. 9th Pacif. Sci. Congr., Bangkok.

Webb, E. K. (1958).—Vanishing potential temperature gradients in strong convection. *Quart. J. R. Met. Soc.* 84 : 118-25.

20. DIVISION OF METROLOGY.

Albrecht, P.—Improvements in router cutters. Aust. Pat. 211705.

Bell, G. A. (1958).—The sharpening of microtome knives. *J. Clin. Path.* 11 (3) : 273.

Bruce, C. F. (1957).—Isotopic light sources and an ultimate wave length definition of length. *Aust. J. Sci.* 19 : 214.

Bruce, C. F. (1957).—Obliquity effects in interferometry. *Opt. Acta* 4 : 127.

Bruce, C. F., *and* Thornton, B. S. (1957).—Obliquity effects in interference microscopes. *J. Sci. Instrum.* 34 : 203.

Bruce, C. F., *and* Thornton, B. S. (1957).—Obliquity effects in interferometry. *Aust. J. Phys.* 10 : 324.

Gibson, A. (1957).—Influence of microstructure on the machinability of a medium carbon steel. *Aust. Mach. & Prod. Engng.* 10 (112) : 13.

Gibson, A. (1958).—Influence of microstructure on the machinability of a medium carbon steel. *Aust. Engr.* 1958 (2) : 56.

Gladman, C. A. (1957).—Production engineering research in Division of Metrology, C.S.I.R.O. *Aust. Mach. & Prod. Engng.* 10 (110) : 13; *Aust. J. Prod. Mgmt.* 1 (3) : 3; *Aust. Engr.* 1957 (11): 64.

Gore, G. W. (1957).—Simple glass sliding joint for vacuum work. *J. Sci. Instrum.* 34 : 459.

Lorenz, G. (1957).—The effect of different gauge addenda on the performance of NOT GO screw plug gauges for unified threads. C.S.I.R.O. Aust. Nat. Stand. Lab. Tech. Pap. No. 9.

Macinante, J. A. (1958).—A smaller Haringx-type vibration isolating table. *J. Sci. Instrum.* 35 : 224.

Mayer, I. F. (1957).—The presentation of results of aerial camera calibration. *Photogrammetria* 13 (2): 49.

Thornton, B. S. (1957).—The effects of collimation and oblique incidence on the visibility of interference fringes. *Opt. Acta* 4 : 147.

21. MINERAGRAPHIC INVESTIGATIONS.

Baker, G. (1957).—Nirranda strewnfield australites, south-east of Warrnambool, Western Victoria. *Mem. Nat. Mus., Melb.* 1957 (20) : 59-172.

Baker, G. (1957).—Natural black glass resembling australite fragments. *Mem. Nat. Mus., Melb.* 1957 (20) : 173-90.

Baker, G. (1957).—Alleged meteorite from Horsham, Victoria. *Mem. Nat. Mus., Melb.* 1957 (21) : 72-8.

Baker, G. (1957).—The role of australites in aboriginal customs. *Mem. Nat. Mus., Melb.* 1957 (22) : 1-23.

Edwards, A. B. (1958).—Microscopical examination of gold-smelting products. *Indian Min. J.* 5 (Spec. Issue) : 317-9.

Edwards, A. B. (1958).—Wave cut platforms at Yampi Sound in the Buccaneer Archipelago, Western Australia. *J. Roy. Soc. W. Aust.* 41 : 17-21.

Edwards, A. B. (1958).—Amphibolites of the Broken Hill district. *J. Geol. Soc. Aust.* 5 : 1-32.

McAndrew, J. (1957).—Natural radiation damage in albite. *Amer. J. Sci.* 255 : 715-23.

McAndrew, J., *and* Stillwell, F. L. (1957).—Pyrosmalite in the Broken Hill Lode, New South Wales. *Min. Mag.* 31 : 371-80.

Threadgold, I. M. (1958).—Mineralization at the Morning Star Gold Mine, Wood's Point, Victoria. *Proc. Aust. Inst. Min. Met.* No. 185 : 1-27.

Williams, K. L. (1958).—Tin-tungsten mineralization at Moina, Tasmania. *Proc. Aust. Inst. Min. Met.* No. 185 : 29-50.

---

* Division of Animal Health and Production, C.S.I.R.O.

† Division of Food Preservation and Transport, C.S.I.R.O.

22. ORE-DRESSING INVESTIGATIONS (MELBOURNE).

Cornelius, R. J., *and* Woodcock, J. T. (1958).—Pressure leaching of a manganese ore. Part I—Kinetic aspects. *Proc. Aust. Inst. Min. Met.* No. 185 : 65-107.

Cornelius, R. J., *and* Woodcock, J. T. (1958).—Pressure leaching of a manganese ore. Part II—Leaching aspects. *Proc. Aust. Inst. Min. Met.* No. 185 : 109-33.

Dunkin, H. H. (1958).—Ore dressing developments in Australia, 1957. *Chem. Engng. Min. Rev.* 50 (6) : 43-50, (7) 40-9.

Hudson, S. B., *and* Blaskett, K. S. (1958).—Recovery of monazite from the beach sand deposits of eastern Australia. *Proc. Aust. Inst. Min. Met.* No. 186 : 161-85.

23. PHYSICAL METALLURGY SECTION.

Corbett, J. A. (1958).—The determination of manganese in titanium. *Analyst* 83 : 53.

Gifkins, R. C. (1957).—The effect of prior strain on the creep of high-purity lead. *J. Aust. Inst. Met.* 2 : 66-71.

Gifkins, R. C. (1957).—The effect of stress on the recrystallization of lead during creep. *J. Inst. Met.* 86 : 15-16.

Gifkins, R. C. (1957).—A surface effect of boundary sliding during creep. *Bull. Inst. Met.* 3 : 185-6.

Gifkins, R. C. (1958).—Oxygen as an impurity in high-purity lead. *Acta Met.* 6 : 132-3.

Miller, D. R. (1958).—Sulphide precipitation from O.F.H.C. copper. *Bull. Inst. Met.* 4 : 35-6.

24. DIVISION OF PHYSICS.

Birch, J. A., Kemp, W. R. G., *and* Klemens, P. G. (1958).—The lattice thermal conductivity of a gold-platinum alloy. *Proc. Phys. Soc. Lond.* B 71 : 843.

Blevin, W. R. (1958).—Ambient temperature effects in the photometry of fluorescent lamps. *Trans. Illum. Engng. Soc.* 23 : 84.

Bray, R. J., *and* Loughhead, R. E. (1957).—Bright regions in sunspots. *Observatory* 77 : 201.

Bray, R. J., *and* Loughhead, R. E. (1958).—The lifetime of sunspot penumbra filaments. *Aust. J. Phys.* 11 : 185.

Giovanelli, R. G. (1957).—An abrupt flare on September 6, 1956. *Observatory* 77 : 238.

Giovanelli, R. G., *and* McCabe, Marie K. (1958).—The distribution of flare heights as derived from limb flares. *Aust. J. Phys.* 11 : 130.

Giovanelli, R. G., *and* McCabe, Marie K. (1958).—The flare-surge event. *Aust. J. Phys.* 11 : 191.

Jefferies, J. T. (1957).—Temperatures and electron densities in flares as derived from spectroscopic data. *Mon. Not. R. Astr. Soc.* 117 : 493.

Kemp, W. R. G., Klemens, P. G., *and* Tainsh, R. J. (1957).—Lattice thermal conductivity of some copper alloys. *Aust. J. Phys.* 10 : 454.

Klemens, P. G. (1957).—Some scattering problems in conduction theory. *Canad. J. Phys.* 35 : 441.

Klemens, P. G. (1957).—Thermal resistance due to isotopic mass variation. *Proc. Phys. Soc. Lond.* A 70 : 833.

Loughhead, R. E., *and* Bray, R. J. (1958).—The Wilson effect in sunspots. *Aust. J. Phys.* 11 : 177.

Loughhead, R. E., *and* Burgess, V. R. (1958).—High resolution cinematography of the solar photosphere. *Aust. J. Phys.* 11 : 35.

Loughhead, R. E., Roberts, J. A., *and* McCabe, Marie K. (1957).—The association of solar radio bursts of spectral type III with chromospheric flares. *Aust. J. Phys.* 10 : 483.

Steel, W. H. (1957).—The use of partial coherence in diffraction theory and antenna design. Proc. Symp. Communication Theory and Antenna Design. AFCRS-TR-57-105. U.S. Department of Commerce, Washington.

Wylie, R. G.—Improvements relating to hygrometers. U.K. Pat. 779307.

Wylie, R. G. (1957).—A new absolute method of hygrometry. I. General principles of the method. *Aust. J. Phys.* 10 : 351.

Wylie, R. G. (1957).—A new absolute method of hygrometry. II. The properties of potassium chloride crystal elements. *Aust. J. Phys.* 10 : 429.

25. DIVISION OF PLANT INDUSTRY.

Andrew, C. S., *and* Bryan W. W. (1958).—Pasture studies on the coastal lowlands of subtropical Queensland. III. The nutrient requirements and potentialities of *Desmodium uncinatum* and white clover on a lateritic podzolic soil. *Aust. J. Agric. Res.* 9 : 267-85.

Angell, H. R. (1957).—The relation of districts and of blue mould in seed beds to loss of tobacco in fields in north Queensland. *J. Aust. Inst. Agric. Sci.* 23 : 144-7.

Badger, G. M., Clark, D. J., Davies, W., Farrer, K. T. H., and Kefford N. P. (1957).—Thionaphthencarboxylic acids. *J. Chem. Soc.* 1957 : 2624-30.

Barnard, C. (1957).—Floral histogenesis in the monocotyledons. I. The Gramineae. *Aust. J. Bot.* 5 : 1-20.

Barnard, C. (1957).—Floral histogenesis in the monocotyledons. II. The Cyperaceae. *Aust. J. Bot.* 5 : 115-28.

Barrow, N. J. (1957).—A source of error in pot experiments with sulphur. *J. Aust. Inst. Agric. Sci.* 23 : 339.

Barrow, N. J. (1957).—Renovation of phalaris pastures with special reference to nitrogen and sulphur relationships. *Aust. J. Agric. Res.* 8 : 617-34.

Bergersen, F. J. (1957).—The structure of ineffective root nodules of legumes: an unusual new type of ineffectiveness, and an appraisal of present knowledge. *Aust. J. Biol. Sci.* 10 : 233-42.

Bergersen, F. J., Brockwell, J., and Thompson, J. A. (1958).—Clover seed pelleted with bentonite and organic material as an aid to inoculation with nodule bacteria. *J. Aust. Inst. Agric. Sci.* 24 : 158-60.

Bergersen, F. J., *and* Merz, B. E. (1958).—A modified capillary microrespirometer. *J. Gen. Physiol.* 41 : 669-74.

Bergersen, F. J., *and* Nutman, P. S. (1957).—Symbiotic effectiveness in nodulated red clover. IV. The influence of the host factors i_1 and *ie* upon nodule structure and cytology. *Heredity* 11 : 175-84.

Bromfield, S. M. (1957).—The solution of manganese oxide by iron sources used in nutrient solutions. *Plant & Soil* 8 : 389-94.

Brown, R., *and* Possingham, J. V. (1957).—Iron deficiency and the growth of pea roots. *Proc. Roy. Soc.* B 147 : 145-66.

Coaldrake, J. E., *and* Haydock, K. P. (1958).—Soil phosphate and vegetal pattern in some natural communities of south-eastern Queensland. *Geology* 39 : 1-4.

Cohen, M., Siegal, A., Zaitlin, M. A., Hudson, W. R., *and* Wildman, S. G. (1957).—A study of tobacco mosaic virus strain predominance and an hypothesis for the origin of systemic virus infection. *Phytopathology* 47 : 694.

Coleman R. G. (1958).—Occurrence of ornithine in sulphur-deficient flax and the possible place of ornithine and citrulline in the arginine metabolism of some higher plants. *Nature* 181 : 776-7.

Costin, A. B. (1957).—The high mountain vegetation of Australia. *Aust. J. Bot.* 5 : 173-89.

Costin, A. B. (1957).—Further evidence of Pleistocene glaciation in the Victorian Alps. *Proc. Linn. Soc. N.S.W.* 82 : 233-8.

Costin, A. B. (1957).—A glacial mill and millstone from Mount Bogong, Victoria. *Proc. Linn. Soc. N.S.W.* 82 : 239.

Costin, A. B. (1958).—Grazing factor and catchment in the Australian Alps. C.S.I.R.O. Aust. Div. Plant Ind. Tech. Pap. No. 10.

Cruickshank, I. A. M. (1958).—Environment and sporulation in phytopathogenic fungi. I. Moisture in relation to the production and discharge of conidia of *Peronospora tabacina* Adam. *Aust. J. Biol. Sci.* 11 : 162-70.

Cruickshank, I. A. M., *and* Muller, K. O. (1957).—Water-relations and sporulation of *Peronospora tabacina* Adam. *Nature* 180 : 44-5.

Evans, L. T. (1957).—The broad bean. *In* Went, F. W. " Experimental Control of Plant Growth." Chap. 8. *Chron. Bot.* 17 : 124-8.

Falk, J. E., *and* Nyholm, R. S. (1958).—Spectrum and bond-type in metalloporphyrins. *In* " Current Trends in Heterocyclic Chemistry ". pp. 130-8. (Butterworth : London.)

Frankel, O. H. (1957).—The biological system of plant introduction. *J. Aust. Inst. Agric. Sci.* 23 : 302-7.

Frankel, O. H. (1958).—The dynamics of plant breeding. *J. Aust. Inst. Agric. Sci.* 24 : 112-23.

Frankel, O. H., *and* Williams, J. D. (1958).—A record of natural crossing in subterranean clover. *J. Aust. Inst. Agric. Sci.* 24 : 162-3.

Giles, J. E., *and* Hutton, E. M. (1958).—Combining resistance to the root-knot nematode, *Meloidogyne javanica* (Treub) Chitwood, and fusarium wilt in hybrid tomatoes. *Aust. J. Agric. Res.* 9 : 182-92.

Goldacre, P. L., *and* Unt, H. (1957).—Effects of 2 : 6-diaminopurine on the growth of roots of subterranean clover. *Nature* 179 : 877-8.

Greenham, C. G. (1958).—α-Fluoro derivatives of 2,4-dichlorophenoxyacetic acid. *Aust. J. Sci.* 20 : 212-13.

Greenham, C. G., *and* Brown, A. C. (1957).—The control of mistletoe by trunk injection. *J. Aust. Inst. Agric. Sci.* 23 : 308-18.

Greenham, C. G., *and* Daday, H. (1957).—Electrical determination of cold hardiness in *Trifolium repens* L. and *Medicago sativa* L. *Nature* 180 : 541-3.

Griffing, B. (1957).—Appendix to paper by M. J. D. White 1957. Cytogenetics of the grasshopper *Moraba scurra.* II. Heterotic systems and their interaction. *Aust. J. Zool.* 5 : 330-7.

Hall, W. A. (1958).—Discussion of " Permeability and infiltration relationships in one dimensional infiltration in a uniform soil ". *Trans. Amer. Geophys. Un.* 39 : 123-4.

Hartley, W. (1958).—Studies on the origin, evolution, and distribution of the Gramineae. I. The tribe Andropogoneae. *Aust. J. Bot.* 6 : 116-28.

Hegarty, M. P. (1957).—The isolation and identification of 5-hydroxy-piperidine-2-carboxylic acid from *Leucaena glauca* Benth. *Aust. J. Chem.* 10 : 484-8.

Helms, Katie (1958).—Witches' broom disease of lucerne. III. A greenhouse study on symptom expression and growth in relation to frequency of watering and cutting. *Aust. J. Agric. Res.* 9 : 319-27.

Hilder, E. J. (1957).—Seasonal pasture production. *Proc. Aust. Soc. Anim. Prod.* 1 : 38-44.

Hill, A. V. (1957).—Blue mould of tobacco. C.S.I.R.O. Aust. Div. Plant Ind. Tech. Pap. No. 9.

Hutton, E. M. (1957).—Some effects of induced autopolyploidy in white clover, barrel medic, and Wimmera ryegrass. *J. Aust. Inst. Agric. Sci.* 23 : 227-31.

Hutton, E. M., Windrum, G. M., *and* Kratzing, C. C. (1958).—Studies on the toxicity of *Indigofera endecaphylla.* I. Toxicity for rabbits. *J. Nutn.* 64 : 321.

Jerome, S. M. R. (1958).—Brown rot of stone fruits. Latent contamination in relation to spread of disease. *J. Aust. Inst. Agric. Sci.* 24 : 132-9.

Johnson, C. M., Huston, R. P., *and* Ozanne, P. G. (1958).—Measurement of microgram amounts of chlorine in plant materials. *J. Agric. Fd. Chem.* 6 : 114-19.

Jones, L. H. P. (1957).—The relative content of manganese in plants. *Plant & Soil* 8 : 328-36.

Jones, L. H. P. (1957).—The effect of liming a neutral soil on the uptake of manganese by plants. *Plant & Soil* 8 : 301-14.

Jones, L. H. P. (1957).—The effect of liming a neutral soil on the cycle of manganese. *Plant & Soil* 8 : 315-27.

Jones, L. H. P. (1957).—The solubility of molybdenum in simplified systems and aqueous soil suspensions. *J. Soil Sci.* 8 : 313-27.

Keraitis, K., *and* Ferguson, A. W. (1957).—A simple technique for determining the stability of soil aggregates by wet sieving. *J. Aust. Inst. Agric. Sci.* 23 : 248-9.

Langridge, J. (1957).—The aseptic culture of *Arabidopsis thaliana* (L.) Heynh. *Aust. J. Biol. Sci.* 10 : 243-52.

Langridge, J. (1957).—Effect of day-length and gibberellic acid on the flowering of *Arabidopsis.* *Nature* 180 : 36-7.

Langridge, J. (1958).—A hypothesis of developmental selection exemplified by lethal and semi-lethal mutants of *Arabidopsis.* *Aust. J. Biol. Sci.* 11 : 58-68.

Lawson, E. H., *and* Rossiter, R. C. (1958).—The influence of seed size and seedling rate on the growth of two strains of subterranean clover (*Trifolium subterraneum* L.). *Aust. J. Biol. Sci.* 9 : 286-98.

Mandryk, M. (1957).—Control of blue mould (*Peronospora tabacina* Adam) in infected tobacco seedlings. *J. Aust. Inst. Agric. Sci.* 23 : 319-22.

Milford, R. (1957).—The value of faecal nitrogen and faecal crude fibre in estimating intake of four subtropical grass species. *Aust. J. Agric. Res.* 8 : 359-70.

Moore, C. W. E. (1957).—A study of some soil properties in relation to the invasion of native pastures by *Bothriochloa ambigua* S. T. Blake. *Aust. J. Bot.* 5 : 44-51.

Morley, F. H. W., Daday, H., *and* Peak, J. W. (1957).—Quantitative inheritance in lucerne *Medicago sativa* L. I. Inheritance and selection for winter yield. *Aust. J. Agric. Res.* 8 : 635-51.

Mortimer, P. I. (1957).—A note on *Duboisia myoporoides* R. Br. from the Acacia Plateau, near Killarney, Qld. *Aust. J. Sci.* 20 : 87.

Mortimer, P. I. (1958).—The structure of *iso*pelletierine from *Duboisia myoporoides*. R. Br. *Aust. J. Chem.* 11 : 82-5.

Mortimer, P. I., *and* Wilkinson, S. (1957).—The occurrence of nicotine, anabasine, and *iso*pelletierine in *Duboisia myoporoides*. *J. Chem. Soc.* 1957 : 3967-70.

Müller, K. O. (1957).—Theoretische Betrachtungen zur Epidemiologie anemocherischer Pflanzenkrankheiten. *Z. PflKrankh.* 64 : 402-7.

Myers, L. F., *and* Lipsett, J. (1958).—Competition between skeleton weed (*Chondrilla juncea* L.) and cereals in relation to nitrogen supply. *Aust. J. Agric. Res.* 9 : 1-12.

Nutman, P. S. (1957).—Studies on the physiology of nodule formation. V. Further experiments on the stimulating and inhibitory effects of root secretions. *Ann. Bot., Lond.* 21 : 321-37.

Nutman, P. S. (1957).—Symbiotic effectiveness in nodulated red clover. III. Further studies on inheritance of effectiveness in the host. *Heredity* 11 : 157-73.

Philip, J. R. (1957).—The theory of infiltration: I. The infiltration equation and its solution. *Soil Sci.* 83 : 345-57.

Philip, J. R. (1957).—The theory of infiltration: II. The profile of infinity. *Soil Sci.* 83 : 435-48.

Philip, J. R. (1957).—The theory of infiltration: III. Moisture profiles and relation to experiment. *Soil Sci.* 84 : 163-78.

Philip, J. R. (1957).—Evaporation, and moisture and heat fields in the soil. *J. Met.* 14 : 354-66.

Philip, J. R. (1957).—Remarks on the analytical derivation of the Darcy equation. *Trans. Amer. Geophys. Un.* 38 : 782-4.

Philip, J. R. (1957).—The theory of infiltration: IV. Sorptivity and algebraic infiltration equations. *Soil Sci.* 84 : 257-64.

Philip, J. R. (1957).—The theory of infiltration: V. The influence of the initial moisture content. *Soil Sci.* 84 : 329-39.

Philip, J. R. (1957).—The role of mathematics in soil physics. *J. Aust. Inst. Agric. Sci.* 23 : 293-301.

Philip, J. R. (1957).—The boundary conditions governing fluid motions in porous media. *Aust. J. Phys.* 10 : 587.

Philip, J. R., *and* de Vries, D. A. (1957).—Moisture movement in porous materials under temperature gradients. *Trans. Amer. Geophys. Un.* 38 : 222-32.

Phillips, J. N. (1958).—Physico-chemical studies on solubilized porphyrins. *In* " Current Trends in Heterocyclic Chemistry ". pp. 30-9. (Butterworth: London.)

Purchase, H. F., *and* Nutman, P. S. (1957).—Studies on the physiology of nodule formation. VI. The influence of bacterial numbers in the rhizosphere on nodule initiation. *Ann. Bot., Lond.* 21 : 439-54.

Rijven, A. H. G. C. (1958).—Effects of some inorganic nitrogenous substances on growth and nitrogen assimilation of young plant embryos *in vitro*. *Aust. J. Biol. Sci.* 11 : 142-54.

Robertson, R. N., *and* Martin, D. (1957).—Apple storage in Australia. *J. Aust. Inst. Agric. Sci.* 23 : 183-8.

Roe, R. (1957).—Ley farming. *Proc. Aust. Soc. Anim. Prod.* 1 : 34-7.

Shaw, N. H. (1957).—Bunch spear grass dominance in burnt pastures in south-eastern Queensland. *Aust. J. Agric. Res.* 8 : 325-34.

Spencer, D. (1958).—The reduction and accumulation of nitrate. *Handb. PflPhysiol.* 8 : 201-11.

Spencer, D., Takahashi, H., *and* Nason, A. (1957).—Relationship of nitrite and hydroxylamine reductases to nitrate assimilation and nitrogen fixation in *Azotobacter agile*. *J. Bact.* 73 : 553-62.

de Vries, D. A. (1957).—The electrical conductivity and permittivity of mixtures. *Brit. J. Appl. Phys.* 8 : 301-2.

de Vries, D. A. (1957).—Analysis of porous thermal insulating materials. *Industr. Engng. Chem.* 49 : 1936.

Walker, N. A. (1957).—Ion permeability of the plasmalemma of the plant cell. *Nature* 180 : 94-5.

Walker, N. A. (1958).—Ion permeability of the plasmalemma of the plant cell. *Nature* 181 : 1288-9.

Webb, L. J. (1957).—Catchment deterioration—a combined agricultural and forestry problem. *J. Aust. Inst. Agric. Sci.* 23 : 251-2.

Webb, L. J., *and* Tracey, J. G. (1957).—Ecological and other evidence for soil inheritance at Childers, S. Qld. *Aust. J. Sci.* 20 : 62.

White, M. J. D. (1957).—Some general problems of chromosomal evolution and speciation in animals. " Survey of Biological Progress." Vol. 3. pp. 109-47. (Academic Press Inc. : New York.)

White, M. J. D. (1957).—Cytogenetics of the grasshopper *Moraba scurra*. I. Meiosis of interracial and interpopulation hybrids. *Aust. J. Zool.* 5 : 285-304.

White, M. J. D. (1957).—Cytogenetics of the grasshopper *Moraba scurra*. II. Heterotic systems and their interaction. *Aust. J. Zool.* 5 : 305-37.

White, M. J. D. (1957).—Cytogenetics of the grasshopper *Moraba scurra*. IV. Heterozygosity for " elastic constrictions ". *Aust. J. Zool.* 5 : 348-54.

White, M. J. D. (1957).—An interpretation of the unique sex-chromosome mechanism of the rodent *Ellobius lutescens* Thomas. *Prod. Zool. Soc., Beng.*, Mookarjee Memor. Vol. 1957 : 113-14.

White, M. J. D., *and* Chinnick, L. J. (1957).—Cytogenetics of the grasshopper *Moraba scurra*. III. Distribution of the 15- and 17-chromosome races. *Aust. J. Zool.* 5 : 338-47.

Williams, O. B. (1957).—The effect of irrigated pasture in the rice rotation on seed populations of *Echinochloa crus-pavonis*. *J. Aust. Inst. Agric. Sci.* 23 : 331-3.

Yen, D. E., *and* Cruickshank, I. A. M. (1957).—The breeding of peas resistant to fusarium wilt. *N.Z. J. Sci. Tech.* 38A : 702-5.

Zaitlin, M. (1958).—Continuous filter paper electrophoresis of tobacco mosaic virus. *J. Chromatog.* 1 : 186-99.

26. POLLEN RESEARCH UNIT, DEPARTMENT OF BOTANY, UNIVERSITY OF MELBOURNE.

Cookson, Isabel C., *and* Dettman, Mary E. (1958).—Cretaceous megaspores and a closely associated microspore from the Australian region. *Micropalaeontology* 4 : 39-49.

Cookson, Isabel C., *and* Eisenack, A. (1958).—Microplankton from Australian and New Guinea Upper Mesozoic sediments. *Proc. Roy. Soc. Vict.* 70 : 19-78.

27. DIVISION OF RADIOPHYSICS.

Adderley, E. E., *and* Twomey, S. (1958).—An experiment on artificial stimulation of precipitation in the Snowy Mountains region of Australia. *Tellus* 10 : 275-80.

Bigg, E. K. (1957).—The fragmentation of freezing water drops. *Bull. Obs. du Puy de Dome* 1957 (3) : 65-9.

Bigg, E. K. (1957).—A new technique for counting ice-forming nuclei in aerosols. *Tellus* 9 : 394-400.

Bigg, E. K. (1957).—January anomalies in cirriform cloud coverage over Australia. *J. Met.* 15 : 524-6.

Bigg, E. K., *and* Macklin, W. C. (1957).—The temperature dependence of ice crystal forms. *Bull. Obs. du Puy de Dome* 1957 (3) : 71-4.

Bolton, J. G., *and* Slee, O.B. (1957).—"Apparent Intensity Variations of the Radio Source Hydra A." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst. pp. 174-8. (Cambridge University Press.)

Bowen, E. G. (1957).—A prediction of a meteor orbital period. *Observatory* 77 : 99-102.

Bowen, E. G. (1957).—Relation between meteor showers and the rainfall of August, September, and October. *Aust. J. Phys.* 10 : 412-17.

Christiansen, W. N., *and* Mathewson, D. S. (1958).—Scanning the Sun with a highly directional array. *Proc. Inst. Radio Engrs., N.Y.* (Special Issue on Radio Astronomy) 46 : 127-31.

Christiansen, W. N., Mathewson, D. S., *and* Pawsley, J. L. (1957).—Radio pictures of the Sun. *Nature* 180 : 944-6.

Christiansen, W. N., Warburton, J. A., *and* Davies, R. D. (1957).—The distribution of radio brightness over the solar disk at a wavelength of 21 centimetres. IV. The slowly varying component. *Aust. J. Phys.* 10 : 491-514.

Davies, L. W. (1957).—Low-high conductivity junctions in semiconductors. *Proc. Phys. Soc. Lond.* B 70 : 885-9.

Davies, L. W. (1958).—The reduction of misalignment voltage in Hall measurements. *J. Sci. Instrum.* 35 : 111.

Davies, L. W. (1958).—The ultimate distribution of impurity in the zone-melting process. *Phil. Mag.* 3 : 159-62.

Edwards, W. D. (1958).—An insulated vacuum lead-in using an O Ring. *J. Sci. Instrum.* 35 : 111-12.

Fletcher, N. H. (1958).—Time lag in ice crystal nucleation in the atmosphere. Part II.—Theoretical. *Bull. Obs. du Puy de Dome* 1958 (1).

Gardner, F. F., *and* Shain, C. A. (1958).—Further observations of radio emission from the planet Jupiter. *Aust. J. Phys.* 11 : 55-69.

Kerr, F. J. (1958).—A 21 centimetre view of the whole Galaxy. *Astrophys. J.* 63 : 51.

Kerr, F. J., *and* Hindman, J. V. (1957).—Mass distribution of galactic neutral hydrogen. *Publ. Astron. Soc. Pacif.* 69 : 558-60.

Kerr, F. J., Hindman, J. V., *and* Carpenter, Martha Stahr 1957).—The large-scale structure of the Galaxy. *Nature* 180 : 677-9.

Komesaroff, M. (1958).—Polarization measurements of the three spectral types of solar radio burst. *Aust. J. Phys.* 11 : 201-14.

Little, A. G. (1958).—Gain measurements of large aerials used in interferometer and cross-type radio telescopes. *Aust. J. Phys.* 11 : 70-8.

Loughhead, R. E., Roberts, J. A., *and* McCabe, Marie K. (1957).—The association of solar radio bursts of spectral Type III., with chromospheric flares. *Aust. J. Phys.* 10 : 483-90.

Mainstone, J. S., Elford, W. G., *and* Weiss, A. A. (1958).—A suggested improvement to the C.W. technique for measurement of meteor velocities. *Aust. J. Phys.* 11 : 277-8.

Mills, B. Y., Little, A. G., Sheridan, K. V., *and* Slee, O.B. (1958).—A high resolution radio telescope for use at 3.5 m. *Proc. Inst. Radio Engrs., N.Y.* (Special Issue on Radio Astronomy) 46 : 67-84.

Pawsey, J. L. (1957).—"Current Progress in Development and Results Obtained with the 'Mills Cross' at the Radiophysics Laboratory." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst, pp. 123-31. (Cambridge University Press.)

Pawsey, J. L. (1957).—"Preliminary Statistics of Discrete Sources obtained with the 'Mills Cross'." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst. pp. 228-32. (Cambridge University Press.)

Pawsey, J. L. (1957).—"Observations of Brightness over the Disk of the Quiet Sun at Frequencies of 85, 500, and 1400Mc/s." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst. pp. 284-9. (Cambridge University Press.)

Pawsey, J. L. (1957).—"President's Report and Proceedings of Commission 40 of the I.A.U. at Ninth General Assembly, Dublin, 1955." Trans. Int. Astron. Un. 9 : 563-91. (Cambridge University Press.)

Pawsey, J. L. (1957).—"Vistas in Radio Astronomy." Aust. Acad. Sci. Year Book, 1957, pp. 65-80.

Pawsey, J. L. (1957).—Radar observations of lightning on 1.5 metres. *J. Atmos. Terr. Phys.*, 11 : 289-90.

Piddington, J. H. (1956).—Hydromagnetic shocks and the creation of magnetic field. *Observatory* 76 : 206-7.

Piddington, J. H. (1957).—Galactic turbulence and the origins of cosmic rays and the galactic magnetic field. *Aust. J. Phys.* 10 : 515-29.

Piddington, J. H. (1957).—Crab Nebula and the origin of interstellar magnetic fields. *Aust. J. Phys.* 10 : 530-46.

Piddington, J. H. (1958).—Cosmical eletrodynamics. *Proc. Inst. Radio Engrs., N.Y.* (Special Issue on Radio Astronomy) 46 : 349-55.

Piddington, J. H. (1958).—Some effects of hydromagnetic waves in the solar atmosphere. Proc. Symp. Electromagnetic Phenomena in Cosmical Physics. August, 1956, Stockholm.

Rishbeth, H., *and* Little, A. G. (1957).—A lunar occultation of the radio source associated with Kepler's supernova. *Observatory* 77 : 71-4.

Roberts, J. A. (1958).—Evidence of echoes in the solar corona from a new type of radio burst. *Aust. J. Phys.* 11 : 215-34.

Shain, C. A. (1957).—"Location on Jupiter of a Source of Radio Noise." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst., pp. 397-9. (Cambridge University Press.)

Shain, C. A. (1957).—A remarkable southern meteor shower. *Observatory* 77 : 27-8.

Shain, C. A. (1958).—The Sydney 19.7 Mc/s radio telescope. *Proc. Inst. Radio Engrs., N.Y.* (Special Issue on Radio Astronomy) 46 : 85-8.

Shain, C. A., *and* Slee, O. B. (1957).—A radio search for comet Arend-Roland. *Observatory* 77 : 204.

Slee, O. B. (1958).—Radio scintillations of Satellite 1958-α. *Nature* 181 : 1710-12.

Smerd, S. F., *and* Wild, J. P. (1957).—"Interpretation of Solar Radio-frequency Disk Brightness Distributions Derived from Observations with Aerials Extended to One Dimension." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst., pp. 290-3. (Cambridge University Press.)

Smith, E. J., Heffernan, K. J., *and* Thompson, W. J. (1958).—The decay of the ice nucleating properties of silver iodide released from an aircraft. *Quart. J. R. Met. Soc.* 84 : 162-5.

Squires, P. (1957).—The equatorial clouds of Jupiter. *Astrophys. J.* 126 : 185-94.

Squires, P. (1958).—The microstructure and colloidal stability of warm clouds. Part I.—The relation between structure and stability. *Tellus* 10 : 256-61.

Squires, P. (1958).—The microstructure and colloidal stability of warm clouds. Part II.—The causes of the variations in microstructure. *Tellus* 10 : 262-71.

Squires, P., *and* Twomey, S. (1957).—Some observations of sea-salt nuclei in Hawaii during Project Shower. *Tellus* 9 : 538-40.

Squires, P., *and* Twomey, S. (1958).—Some observations relating to the stability of warm cumuli. *Tellus* 10 : 272-4.

Squires, P., *and* Warner, J. (1957).—Some measurements in the orographic cloud of the Island of Hawaii and in trade wind cumuli. *Tellus* 9 : 475-94.

Twiss, R. Q., *and* Hanbury Brown, R. (1957).—The question of correlation between photons in coherent beams of light. *Nature* 179 : 1128-9.

Twiss, R. Q., Little, A. G., *and* Hanbury Brown R. (1957).—The correlation between photons, in coherent beams of light, detected by a coincidence counting technique. *Nature* 180 : 324-6.

Twomey, S. (1957).—Electric charge separation in subfreezing cumuli. *Tellus* 9 : 384-93.

de Vaucouleurs, G., *and* Sheridan, K. V. (1957).—" Radio and Optical Distributions in the Centaurus Source (NGC 5128)." International Astronomical Union, Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst. pp. 169-73. (Cambridge University Press.)

Warburton, J. A. (1958).—Rainmaking in Australia. *Chem. Engng. Min. Rev.* 50 : 40-3.

Warner, J. (1957).—An instrument for the measurement of freezing nucleus concentration. *Bull. Obs. du Puy de Dome* 1957 (2): 33-46.

Warner, J., *and* Newnham, T. D. (1958).—Time lag in ice crystal nucleation in the atmosphere. Part I.—Experimental. *Bull. Obs. du Puy de Dome* 1958 (1) : 1-10.

Weiss, A. A. (1958).—The 1956 Phoenicid meteor shower. *Aust. J. Phys.* 11 : 113-17.

Weiss, A. A. (1957).—The incidence of meteor particles upon the Earth. *Aust. J. Phys.* 10 : 397-411.

Wild, J. P. (1957).—" Radio Observations of Solar Flares." *Trans. Int. Astron. Un.* 9 : 661-3. (Cambridge University Press.)

Wild, J. P. (1957).—" Spectral Observations of Solar Activity at Metre Wavelengths." International Astronomical Union Symposium No. 4: Radio Astronomy. Ed. H. C. van de Hulst. pp. 321-6. (Cambridge University Press.)

Wild, J. P., *and* Sheridan, K. V. (1958).—A swept-frequency interferometer for the study of high-intensity solar radiation at metre wavelengths. *Proc. Inst. Rad. Engrs., N.Y.* (Special Issue on Radio Astronomy) 46 : 160-71.

28. Radio Research Laboratories.

Duncan, R. A. (1957).—The measurement of the drift velocity of electrons through gases by the electron shutter method. *Aust. J. Phys.* 10 : 54-9.

Ellis, G. R. (1957).—Cosmic radio noise intensities below 10 Mc/s. *J. Geophys. Res.* 62 : 229.

Ellis, G. R. (1957).—Measurement of the gyro-frequency in the *F* region. *J. Atmos. Terr. Phys.* 11 : 54.

Ellis, G. R. (1957).—Low-frequency radio emission from aurorae. *J. Atmos. Terr. Phys.* 10 : 302.

Ellis, G. R., *and* Newstead, G. (1957).—Discrete sources of cosmic radio noise at 18.3 and 10.5 Mc/s. *J. Atmos. Terr. Phys.* 10 : 185.

Munro, G. H. (1957).—Anomalies of ionosonde records due to travelling ionospheric disturbance. *J. Geophys. Res.* 62 : 325.

Munro, G. H. (1957).—Travelling disturbance in the ionosphere; changes in diurnal variation. *Nature* 180 : 1252.

Munro, G. H., *and* White, R. B. (1958).—Observations in Australia of radio transmissions from the first artificial earth satellite. *Nature* 181 : 104.

29. Division of Soils.

Beattie, J. A., *and* Haldane, A. D. (1958).—The occurrence of palygorskite and barytes in certain parna soils of the Murrumbidgee region, New South Wales. *Aust. J. Sci.* 20 : 274.

Beckwith, R. S. (1958).—Effects of EDTA on the uptake of micronutrient metals by oats from an organic soil. *Aust. J. Agric. Res.* 9 : 13.

Butler, B. E. (1958).—Depositional systems of the Riverine Plain of South-eastern Australia in relation to soils. C.S.I.R.O. Aust. Soil Publ. No. 10.

Butler, B. E. (1958).—The diversity of concepts about soils. *J. Aust. Inst. Agric. Sci.* 24 : 14.

van Dijk, D. C. (1958).—Principles of soil distribution in the Griffith-Yenda District, New South Wales. C.S.I.R.O. Aust. Soil Publ. No. 11.

Greacen, E. L. (1958).—The soil structure profile under pastures. *Aust. J. Agric. Res.* 9 : 129.

Hubble, G. D. (1958).—The occurrence of strongly acid clays beneath alkaline soils in Queensland. *Aust. J. Sci.* 20 : 186.

Jackson, E. A. (1958).—A study of soils and some aspects of the hydrology at Yudnapinna Station, South Australia. C.S.I.R.O. Aust. Div. Soils, Soils and Land Use Ser. No. 24.

Loveday, J. (1957).—The soils of the Sorell-Carlton-Copping Area, South-east Tasmania, with special reference to the soils formed on basalt. C.S.I.R.O. Aust. Soil Publ. No. 8.

McArthur, W. M. (1957).—Plant ecology of the coastal islands near Fremantle, Western Australia. *J. Roy. Soc. W. Aust.* 40 : 46.

Marshall, T. J. (1957).—Permeability and the size distribution of pores. *Nature* 180 : 664.

Marshall, T. J. (1958).—A relation between permeability and size distribution of pores. *J. Soil Sci.* 9 : 1.

Martin, A. E., *and* Reeve, R. (1958).—Chemical studies of podzolic illuvial horizons: III. Titration curves of organic matter suspensions. *J. Soil. Sci.* 9 : 89.

Norrish, K., *and* Radoslovich, E. W. (1957).—Effect of biotite on the firing characteristics of certain weathered schists. *Clay. Min. Bull.* 3 : 189.

Raupach, M., *and* de Vries, M. P. C. (1958).—Variations in soluble and exchangeable ions with depth in a small area of Riverina clay. *Aust. J. Appl. Sci.* 9 : 192.

Rovira, A. D., *and* Greacen, E. L. (1957).—The effect of aggregate disruption on the activity of microorganisms in the soil. *Aust. J. Agric. Res.* 8 : 659.

Sperber, J. I. (1957).—Solution of mineral phosphates by soil bacteria. *Nature* 180 : 994.

Sperber, J. I. (1958).—Release of phosphate from soi minerals by hydrogen sulphide. *Nature* 181 : 934.

Stephens, C. G., *and* Bond, R. D. (1957).—Nitrogen economy in plantations of *Pinus radiata*. *Aust. For* 21 : 117.

Stephens, C. G. (1958).—The phenology of Australian soils. *Trans. Roy. Soc. S. Aust.* 81 : 1.

Taylor, J. K., *and* Stephens, C. G. (1958).—The soils of South Australia. A.N.Z.A.A.S. Handbook.

Tiller, K. G. (1957).—Some pine-soil relationships in the Mt. Burr Forest Area, South Australia. *Aust. For.* 21 : 97.

Wild, A. (1958).—The phosphate content of Australian soils. *Aust. J. Agric. Res.* 9 : 193.

30. Division of Tribophysics.

Boas, W. (1957).—Lattice defects in plastically deformed metals. *In* " Dislocations and Mechanical Properties of Crystals ". (International Conference at Lake Placid, 1956.) p. 333. (John Wiley & Sons: New York.)

Boas, W. (1957).—Color changes in metals upon plastic deformation. *In* " Dislocations and Mechanical Properties of Crystals ". (International Conference at Lake Placid, 1956.) p. 406. (John Wiley & Sons: New York.)

Clarebrough, L. M. (1957).—Internal friction of β brass. *Acta Met.* 5 : 413.

Clarebrough, L. M., *and* Hargreaves, M. E. (1958).—The energy stored in deformed metals. *J. Aust. Inst. Met.* 3 : 31.

Clarebrough, L. M., Hargreaves, M. E., *and* West, G. W. (1957).—The density of dislocations in compressed copper. *Acta Met.* 5 : 738.

Clarebrough, L. M., Hargreaves, M. E., West, G. W., *and* Head, A. K. (1957).—The energy stored in fatigued metals. *Proc. Roy. Soc.* A 242 : 160.

McDonald, C. G., Temby, A. L., Hargreaves, M. E., *and* Moore, A. J. W. (1957).—Failure of a set of roller bearings. *Wear* 1 : 64.

Mackenzie, J. K. (1957).—General relation between lattice sums. *J. Chem. Phys.* 26 : 1769.

Mackenzie, J. K., *and* Thomson, M. J. (1957).—Some statistics associated with random disorientation of cubes. *Biometrika* 44 : 205.

Michell, D. (1958).—Comments on " X-ray and calorimetric investigations of cold working and annealing of a gold-silver alloy ". *Acta Met.* 6 : 141.

Moore, A. J. W. (1958).—The influence of surface energy on thermal etching. *Acta Met.* 6 : 293.

Vines, R. G. (1957).—Thermal conduction in gases. Proc. Conf. on Thermodynamic and Transport Properties of Fluids. p. 120.

31. Wildlife Survey Section.

Carrick, R. (1957).—What is the best free-feeding system for furrow-poisoning the rabbit? *C.S.I.R.O. Wildl. Res.* 2 : 78-84.

Carrick, R., Wheeler, W. R.,[*] *and* Murray, M. D.[†] (1957).—Seasonal dispersal and mortality in the silver gull, *Larus novae-hollandiae* Stephens, and crested tern, *Sterna bergii* Lichtenstein, in Australia. *C.S.I.R.O. Wildl. Res.* 2 : 116-44.

Carrick, R., Keith, Noel, *and* Keith, K. (1957).—Third annual report of Australian bird-banding scheme, July, 1956, to June, 1957. *C.S.I.R.O. Wildl. Res.* 2 : 145-63.

Davies, S. J. J. F. (1957).—The gosling of the magpie goose. *Emu* 57 : 354-5.

Dunnet, G. M. (1957).—Notes on avian predation on young rabbits, *Oryctolagus cuniculus* (L.). *C.S.I.R.O. Wildl. Res.* 2 : 66-8.

Dunnet, G. M. (1957).—Notes on emergence behaviour of the rabbit, *Oryctolagus cuniculus* (L.), and its bearing on the validity of sight counts for population estimates. *C.S.I.R.O. Wildl. Res.* 2 : 85-9.

Dunnet, G. M. (1957).—A test of the recapture method of estimating the number of rabbits, *Oryctolagus cuniculus* (L.), in a warren. *C.S.I.R.O. Wildl. Res.* 2 : 90-100.

English, Kathleen M. I.,[*] Mackerras, I. M.,[†] *and* Dyce, A. L. (1957).—Notes on the morphology and biology of a new species of *Chalybosoma* (Diptera, Tabanidae). *Proc. Linn. Soc. N.S.W.* 82 : 289-96.

Fennessy, B. V. (1958).—Control of the European rabbit in New Zealand. C.S.I.R.O. Wildl. Surv. Sect. Tech. Pap. No. 1.

Frith, H. J. (1957).—Breeding and movements of wild ducks in inland New South Wales. *C.S.I.R.O. Wildl. Res.* 2 : 19-31.

Frith, H. J. (1957).—Wild ducks and the rice industry in New South Wales. *C.S.I.R.O. Wildl. Res.* 2 : 32-50.

Frith, H. J. (1957).—Aberrant wood duck, *Chenonetta jubata* (Latham). *C.S.I.R.O. Wildl. Res.* 2 : 69.

Frith, H. J. (1957).—Experiments on the control of temperature in the mound of the mallee-fowl, *Leipoa ocellata* Gould (Megapodiidae). *C.S.I.R.O. Wildl. Res.* 2 : 101-10.

Gilmour, D.,[‡] *and* Griffiths, M. (1957).—The effect of 2, 4-dinitrophenol on myosin. *Arch. Biochem. Biophys.* 72 : 302.

Guiler, E. R.,[§] Serventy, D. L., and Willis, J. H.[‖] (1958).—The Fisher Island Field Station—with an account of its principal fauna and flora. *Pap. Roy. Soc. Tas.* 92 : 165-83.

Lee, D. J.,[¶] Dyce, A. L., *and* O'Gower, A. K.[¶] (1957).—Blood-sucking flies (Diptera) and myxomatosis transmission in a mountain environment in New South Wales. *Aust. J. Zool.* 5 : 355-401.

Marlow, B. J. (1957).—A recent record from New South Wales of the rufous rat-kangaroo, *Aepyprymnus rufescens* (Gray) (Macropodidae). *C.S.I.R.O. Wildl. Res.* 2 : 166-7.

Meldrum, G. K.,[**] Bignell, J. T.,[**] *and* Rowley, Ian 1957).—The use of sodium fluoroacetate (compound 1080) for the control of the rabbit in Tasmania. *Aust. Vet. J.* 33 : 186-96.

Mollison, B. C. (1957).—A live-trap for birds. *C.S.I.R.O. Wildl. Res.* 2 : 172-4.

Myers, K. (1957).—Observations on the sampling of mosquito larvae and pupae in the field. *C.S.I.R.O. Wildl. Res.* 2 : 111-15.

Myers, K. (1957).—Some observations on the use of sight counts in estimating populations of the rabbit, *Oryctolagus cuniculus* (L.). *C.S.I.R.O. Wildl. Res.* 2 : 170-2.

Mykytowycz, R. (1957).—The transmission of myxomatosis by *Simulium melatum* Wharton (Diptera: Simuliidae). *C.S.I.R.O. Wildl. Res.* 2 : 1-4.

Mykytowycz, R. (1957).—Ectoparasites of the wild rabbit, *Oryctolagus cuniculus* (L.), in Australia. *C.S.I.R.O. Wildl. Res.* 2 : 63-5.

Mykytowycz, R. (1957).—Parasitic habit of the rabbit mite, *Cheyletiella parasitivorax* (Megnin). *C.S.I.R.O. Wildl. Res.* 2 : 164.

Mykytowycz, R., *and* Hesterman, E. R. (1957).—A note on tick infestation of the fairy penguin, *Eudyptula minor* Forster. *C.S.I.R.O. Wildl. Res.* 2 : 165-6.

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Rowley, Ian (1957).—Field enclosure experiments on the technique of poisoning the rabbit, *Oryctolagus cuniculus* (L.). I. A study of total daily take of bait during free-feeding. *C.S.I.R.O. Wildl. Res.* 2 : 5-18.

Rowley, Ian (1957).—Observations on evening rabbit activity in relation to weather and sunset. *C.S.I.R.O. Wildl. Res.* 2 : 168-9.

Rowley, Ian (1957).—Co-operative feeding of young by superb blue wrens. *Emu* 57 : 356-7.

Serventy, D. L. (1957).—The banding programme on *Puffinus tenuirostris* (Temminck). I. First report. *C.S.I.R.O. Wildl. Res.* 2 : 51-9.

Serventy, D. L. (1957).—Duration of immaturity in the short-tailed shearwater, *Puffinus tenuirostris* (Temminck). *C.S.I.R.O. Wildl. Res.* 2 : 60-2.

32. Wool Textile Research Laboratories.

Bradbury, J. H. (1957).—A new approach to the determination of the accessibility of wool to sorbates. *Text. Res. J.* 27 : 829.

Bradbury, J. H. (1958).—The kinetics of hydrazinolysis of simple peptides in anhydrous hydrazine. *Biochem. J.* 68 : 475.

Bradbury, J. H. (1958).—The hydrazinolysis of insulin, lysozyme, wool proteins and wool. *Biochem. J.* 68 : 482.

Cecil, R., *and* McPhee, J. R. (1957).—Further studies on the reaction of disulphides with silver nitrate. *Biochem. J.* 66 : 538.

Crewther, W. G., *and* Pressley, T. A. (1957).—Recent developments in wool carbonizing. Proc. Int. Wool Text. Org. Paris Conf. Dec. 1957, Rep. No. 1.

Crewther, W. G., *and* Pressley, T. A. (1958).—Carbonizing investigations. IV. Industrial carbonizing trials to assess the protection of wool by surface active agents added to the acid. *Text. Res. J.* 28 : 67.

Crewther, W. G., *and* Pressley, T. A. (1958).—Carbonizing investigations. V. The effect of moisture content on the action of sulphuric acid on wool: the significance of tests for damage. *Text. Res. J.* 28 : 73.

Delminico, J. (1957).—Melange or vigoureux printing of wool: a method for increasing the rate of dye fixation. *Text. Res. J.* 27 : 899.

Downes, J. G., *and* Mackay, B. M. (1958).—Sorption kinetics of water vapour in wool fibres. *J. Polym. Sci.* 28 : 45.

Ehrenpreis, S., Leach, S. J., *and* Scheraga, H. A. (1957).—Action of thrombin on lysine substrates. *J. Amer. Chem. Soc.* 79 : 6086.

Farnworth, A. J. (1957).—A hydrogen bonding mechanism for the permanent setting of wool fibres. *Text. Res. J.* 27 : 632.

Fraser, R. D. B. (1958).—Interpretation of infra-red dichroism in axially oriented polymers. *J. Chem. Phys.* 28 : 113.

Fraser, R. D. B., *and* MacRae, T. P. (1957).—Molecular organization in keratins. Part I: Introductory survey. *Text. Res. J.* 27 : 379.

Fraser, R. D. B., *and* MacRae, T. P. (1957).—Molecular organization in keratins. Part II: The densities of native keratins. *Text. Res. J.* 27 : 384.

Fraser, R. D. B., *and* MacRae, T. P. (1957).—Molecular organization in keratins. Part III: The densities of physically and chemically modified wool. *Text. Res. J.* 27 : 867.

Fraser, R. D. B., *and* MacRae, T. P. (1958).—The hydrogen-deuterium exchange reaction in α-keratin. *J. Chem. Phys.* 28 : 120.

Fraser, R. D. B., MacRae, T. P., *and* Simmonds, D. H. (1957).—Models of α-keratin structure. *Biochim. Biophys. Acta* 25 : 654.

Gillespie, J. M. (1958).—The isolation from wool of a readily extractable protein of low sulphur content. *Biochim. Biophys. Acta* 27 : 225.

Gillespie, J. M., *and* Springell, P. H. (1957).—The binding of zinc by *S*-carboxymethyl kerateine 2 from wool. *Aust. J. Chem.* 10 : 344.

Griffith, June C., *and* Alexander, A. E. (1957).—The supercontraction of wool in solutions of lithium salts. *Text. Res. J.* 27 : 755.

Haly, A. R. (1958).—Ultra violet irradiation and the wool fibre epicuticle. *Text. Res. J.* 28 : 182.

Haly, A. R., *and* Feughelman, M. (1958).—Application of statistical theory of elastomers to supercontracted keratin fibres. *Text. Res. J.* 27 : 919.

Haly, A. R., Feughelman, M., *and* Griffith, June C. (1957).—Supercontraction of wool irradiated with ultra-violet light or iodinated. *Nature* 180 : 1064.

Haly, A. R., *and* Griffith, June C. (1957).—Penetration of lithium bromide in wool: supercontraction. *Text. Res. J.* 28 : 32.

Human, J. P. E., *and* Lindley, H. (1957).—The reactivity of the disulphide bonds of stretched wool fibres. *Text. Res. J.* 27 : 917.

Jackson, D. L. C.—Improvements in or relating to the treatment of textile materials composed wholly or partly of animal fibre to reduce their tendency to felt. Aust. Pat. 209304.

Jermyn, M. A. (1957).—Separation of monomethylated *p*-nitrophenyl-β-glucosides on a carbon column. *Aust. J. Chem.* 10 : 455.

Jermyn, M. A. (1957).—Synthesis of some substances related to *p*-nitrophenyl-β-glucoside and of 4-*O*-methyl glucose through crystalline intermediates. *Aust. J. Chem.* 10 : 448.

Jermyn, M. A. (1958).—Fungal cellulases. VIII. Further observations on the β-glucosides of *Stachybotrys atra*. *Aust. J. Biol. Sci.* 11 : 114.

Leach, S. J., *and* Scheraga, H. A. (1958).—Preparation, sedimentation and deuterium exchange studies of the oxidised A and B chains of insulin. *C. R. Lab. Carlsberg* (*Ser. Chim.*) 30 : 271.

Leary, B. G. (1958).—An optical transducer for displacement measurements. *Rev. Sci. Instrum.* 29 : 246.

Legge, J. W., Morrieson, S. R., Rogers, G. E., *and* Marginson, M. A. (1957).—The chromatography and counter current distribution of secretin. *Aust. J. Exp. Biol.* 35 : 569.

Lindley, H. (1957).—The elastic properties of chemically modified wools and their implications for theories of wool structure. *Text. Res. J.* 27 : 690.

Lipson, M., *and* McPhee, J. R. (1957).—Mothproofing with dieldrin. Proc. Int. Wool Text. Org. Paris Conf., December 1957, Rep. No. 5.

Maclaren, J. A. (1957).—The reversibility of aromatic nitration. *Proc. Roy. Aust. Chem. Inst.* 24 : 421.

McPhee, J. R. (1957).—Toxicity of lithium salts to keratin-digesting insect larvae. *Nature* 180 : 1001.

McPhee, J. R. (1958).—The reaction of formaldehyde with wool and its effect on digestion by insects. *Text. Res. J.* 28 : 303.

Pressley, T. A. (1957).—Developments in wool carbonizing. *Wool Technol.* 4 : 51.

Pressley, T. A. (1958).—Some aspects of the determination of the regain of Australian scoured wool. Proc. Int. Wool Text. Org. Vienna Conf., May 1958, Rep. No. 12.

Rogers, G. E. (1957).—Electron microscope observations on the glassy layer of the hair follicles. *Exp. Cell Res.* 13 : 521.

Rogers, G. E. (1957).—Electron microscope observations on the structure of sebaceous glands. *Exp. Cell Res.* 13 : 517.

Rogers, G. E. (1958).—Some aspects of the structure of the inner root sheath of hair follicles revealed by light and electron microscopy. *Exp. Cell Res.* 14 : 378.

Simmonds, D. H. (1958).—Automatic equipment for the determination of amino acids separated on columns of ion exchange resins. *Anal. Chem.* 30 : 1043.

Simmonds, D. H. (1958).—The amino acid composition of keratins. V. A comparison of the chemical composition of Merino wools of differing crimp with that of other animal fibres. *Text. Res. J.* 28 : 314.

Springell, P. H. (1957).—Nucleic acids and the biosynthesis of collagen. *Aust. J. Biol. Sci.* 10 : 398.

Swan, J. M. (1957).—Thiols, disulphides and thiosulphates: some new reactions and possibilities in peptide and protein chemistry. *Nature* 180 : 643.

Swan, J. M. (1957).—Pyrimidines. *Proc. Roy. Aust. Chem. Inst.* 24 : 299.

Swan, J. M. (1958).—The possible formation of thiazoline and thiazolidine rings in peptides and proteins. *In* "Current Trends in Heterocyclic Chemistry". p. 65. (Butterworth: London.)

Swan, J. M., *and* Woods, E. F. (1957).—The formation of disulphides during hydrolysis of proteins containing oxidised thioether groups. *Biochim. Biophys. Acta* 25 : 432.

Taylor, D. S. (1957).—Drafting force and its relation to the measurement of fibre—fibre friction. *J. Text. Inst.* 48 : T466.

Thompson, E. O. P. (1957).—The C-terminal amino acid sequence of lysozyme. *Biochim. Biophys. Acta* 25 : 210.

Tracey, M. V., *and* Youatt, G. (1958).—Cellulose and chitinase in two species of Australian termites. *Enzymologia* 19 : 70.

Woods, E. F. (1958).—Electrophoresis of proteins at low pH in amino acid hydrochloride buffers. *J. Phys. Chem.* 62 : 308.

Youatt, G. (1958).—Fungal cellulases. IX. Growth of *Stachybotrys atra* on cellulose and production of a *β*-glucosidase hydrolysing cellobiose. *Aust. J. Biol. Sci.* 11 : 209.

XXXV. FINANCE.

1. EXPENDITURE.

The statement of expenditure from 1st July, 1957, to 30th June, 1958, is as follows:—

	£	£	£
(*a*) Salaries and contingencies			297,725*
(*b*) Investigations—			
(i) Animal Health and Production Problems		737,848	
Less contributions from—			
Wool Research Trust Fund Trust Account	336,126		
Australian Dairy Produce Board	2,330		
Australian Meat Board	199		
Ian McMaster Bequest	6,752		
Alexander Fraser Memorial Fund	306		
Wm. McIlrath Fellowship	2,250		
Burdekin Bequest (Drought feeding)	1,333		
Special Revenue Funds—			
"Belmont" Field Station	2,685		
Special Reserve Fund—			
National Field Station, "Gilruth Plains"	5,973		
		357,954	
			379,894
(ii) Biochemistry and General Nutrition Problems		119,810	
Less contributions from—			
Wool Research Trust Fund Trust Account	42,180		
Australian Wool Board	11		
		42,191	
			77,619
(iii) Plant Problems—Division of Plant Industry		754,835	
Less contributions from—			
Wool Research Trust Fund Trust Account	132,247		
Commonwealth Bank	632		
River Murray Commission and Snowy Mountains Hydro-electric Authority	3,750		
Brown Rot Trust Fund	618		
Wheat Research Trust Account	269		
Special Revenue Fund—Samford Farm	291		
		137,807	
			617,028
(iv) Entomology Problems			215,538
(v) Soils and Irrigation Problems of Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith		64,476	
Less contributions from—			
N.S.W. Water Conservation and Irrigation Commission	2,000		
Special Revenue Fund—Griffith Research Station	10,545		
		12,545	
			51,931
(*b*) Viticultural—Research Station, Merbein		73,639	
Less contributions from—			
Dried Fruits Control Board	1,698		
Mildura Co-op. Fruit Company	1,236		
Irymple Packing Company			
Red Cliffs Co-op. Fruit Company			
Co-op. Dried Fruit Sales Ltd.			
		2,934	
			70,705
			122,636

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* The main items of expenditure under this heading are salaries of the Administrative Staff at the Organization's Head Office; salaries and expenses of officers at the Liaison Offices in London and Washington; staff and upkeep of State Committees; travelling expenses of Head Office Staff; and general office expenditure.

	£	£	£
(vi) Soil Problems	..	22,706	
Less contributions from—			
Department of Supply	510		
Country Roads Board of Victoria	956		
		1,466	
			221,240
(vii) Food Preservation and Transport Problems	..	245,125	
Less contributions from—			
N.S.W. Department of Agriculture	2,036		
Metropolitan Meat Industry Board	477		
Queensland Meat Industry Board	1,171		
Australian Meat Board	368		
Australian Egg Board	635		
Commonwealth Can Makers' Association	615		
Department of Primary Industry	2,357		
Department of Trade	7,386		
Various Contributors	2,785		
Department of Scientific and Industrial Research (U.K.)	242		
Apple and Pear Board	384		
		18,456	
			226,669
(viii) Forest Products Problems	..	316,322	
Less contributions from—			
Australian Paper Manufacturers Ltd. Associated Pulp and Paper Mills Ltd. Australian Newsprint Mills New Zealand Forest Products Ltd.	4,097		
Department of Territories	3,304		
General Donations	1,872		
Pole Strength Research Account	7,324		
Australian Plywood Board	7,328		
		23,925	
			292,397
(ix) Mining and Metallurgy	..	49,406	
Less contributions from—			
Australasian Institute of Mining and Metallurgy	260		
State Electricity Commission	724		
General Donations	3,466		
Territory Enterprises Pty. Ltd.	1,474		
		5,924	
			43,482
(x) Radio Research	..	52,743	
Less contributions from—			
Postmaster-General's Department	14,212		
Australian Broadcasting Control Board and Overseas Telecommunications Commission	3,000		
		17,212	
			35,531
(xi) Research Services	..	278,020	
Less contributions from—			
Wool Research Trust Fund Trust Account	10,439		
		10,439	
			267,581
(xii) Industrial Chemistry	..	624,169	
Less contributions from—			
Cement and Concrete Association of Australia	3,426		
Mt. Morgan Ltd., Mt. Lyell Mining and Railway Co. Ltd., Mt. Isa and Peko N.L.	9,006		
Consolidated Zinc Pty. Ltd	6,737		
Various Contributors	2,459		
Rio Tinto Pty. Ltd	1,953		
Smith, Kline and French Laboratories (U.S.A.)	3,633		
State Electricity Commission, Victoria, Gas and Fuel Corporation, and Australian Paper Manufacturers Ltd.	1,516		
Zircon Rutile Pty. Ltd., Australian Titan Products Pty. Ltd., Western Titanium N.L., and Associated Minerals Consolidated	8,964		
		37,694	
			586,475
(xiii) Fisheries Investigations	..	171,458	
Less contributions from—			
N.S.W. Government	419		
Department of the Navy	3,804		
Department of Primary Industry	2,231		
		6,454	
			165,004
(xiv) Mathematical Statistics	..	..	59,327
(xv) National Standards Laboratory	..	577,186	
Less contributions from—			
Department of Supply	1,547		
General Donations	957		
		2,504	
			574,682
(xvi) Tribophysics	..	..	101,079
(xvii) Building Research	..	149,098	
Less contributions from—			
Associated Fibrous Plaster Manufacturers of Australia	2,332		
Paint Manufacturers' Association	2,535		
State Electricity Commission	588		
		5,455	
			143,643

	£	£	£
(xviii) Fodder Conservation			38,794
(xix) Radiophysics Research		383,672	
Less contributions from—			
Snowy Mountains Hydro-electric Authority	3,651		
		3,651	
			380,021
(xx) Metallurgical Research			11,103
(xxi) Tobacco Research		45,999	
Less contributions from—			
Tobacco Research Trust	45,999		
		45,999	
(xxii) Meteorological Physics			81,695
(xxiii) Dairy Research		70,336	
Less contributions from—			
Australian Dairy Produce Board	3,804		
		3,804	
			66,532
(xxiv) Wool Textile Research		384,823	
Less contributions from—			
Wool Research Trust Fund Trust Account	373,382		
Princeton Institute, U.S.A.	489		
Australian Wool Testing Authority	62		
		373,933	
			10,890
(xxv) Fuel Research			175,792
(xxvi) Wildlife Survey		119,338	
Less contributions from—			
Wool Research Trust Fund Trust Account	54,327		
I.C.I.A.N.Z. Ltd.	346		
Northern Territory Administration	3,946		
Walter & Eliza Hall Institute	250		
		58,869	
			60,469
(xxvii) Land Research and Regional Survey		154,929	
Less contributions from—			
Department of National Development	1,874		
Department of Territories	19,226		
Australian Meat Board	750		
		21,850	
			133,079
(xxviii) Genetics Investigations		62,085	
Less contributions from—			
Wool Research Trust Fund Trust Account	28,778		
N.S.W. State Cancer Council	267		
General Donations	610		
Commonwealth Bank	59		
		29,714	
			32,371
(xxix) Miscellaneous—			
(*a*) Biophysical Research		2,962	
(*b*) Patent Fees		7,409	
(*c*) Extra-mural Investigations		33,300	
(*d*) Furlough and Compensation		13,272	
(*e*) Various		24,394	
		81,337	
Less contributions from—			
Science and Industry Endowment Fund	1,150		
Australian Hide and Leather Industries Board	2,087		
General Donations	32		
Bowen Consolidated Coal Mines	3,750		
Department of Primary Industry	9,002		
Wool Research Trust Fund Trust Account	101		
Wheat Research Trust Account	1,507		
United Graziers' Association of Queensland	172		
		17,801	
			63,536
Total of Item (*b*)—Investigations			5,481,832
(*c*) Grants—			
(i) Research Associations—			
Leather Research Association	6,387		
Bread Research Institute	10,873		
Wine Research Institute	3,500		
Tobacco Research Trust	10,500		
Coal Association (Research) Ltd.	10,000		
		41,260	
(ii) Overseas Research Studentships		60,793	
		102,053	
Less contributions from—			
Wool Research Trust Fund Trust Account	3,127		
Science and Industry Endowment Fund	1,155		
		4,282	
			97,771
Total Salaries and Contingencies, Investigations, and Grants			5,579,603
Less receipts from sales of equipment, publications, &c., and revenue earned by Divisions and Sections, details of which are shown in Section 4			152,501
			5,427,102

2. CONTRIBUTIONS.

This Section shows the receipts and disbursements during the year 1957-58 of the funds provided by contributors and recorded in a special account entitled "Specific Research Trust Fund". It includes transactions financed from wool funds, details of which appear in Section 3 of this Chapter. Of the total expenditure of £1,621,367 recorded in this Fund, £1,281,675 refers to normal research activities and £339,692 to capital works. The following table summarizes the sources of these funds and the activities on which they were expended:—

Source of Funds.	Activity.		Total.
	Investigations.	Capital Works.	
	£	£	£
Wool Research Trust Fund Trust Account	998,507	269,421	1,267,928
Contributions (other than Wool)	283,168	70,271	353,439
	1,281,675	339,692	1,621,367

The details are as follows:—

	Receipts 1957-58 and balances brought forward from 1956-57.	Expenditure 1957-58.
	£	£
Wool Research Trust Fund Trust Account. (Details are shown in Section 3)	1,289,100	1,267,928
Australian Meat Board—Visit of Dr. J. Hammond (Animal Health and Production)	200	200
Australian Dairy Produce Board (Mastitis Investigations)	2,410	2,330
W. McIlrath Research Fellowship Fund (Expenses of Fellowship—Animal Husbandry)	2,250	2,250
Australian Meat Board (Parasitological Studies of Cattle)	6	..
Australian Dairy Produce Board (Parasitological Studies of Cattle)	3	..
Alexander Fraser Memorial Fund (Animal Health and Production Investigations)	427	306
Estate of the late Captain Ian McMaster (Animal Health and Production Investigations)	6,930	6,752
Burdekin Bequest (Drought Feeding Investigations)	2,494	1,333
Special Revenue Fund—"Belmont" Field Station, Rockhampton (Animal Health and Production Investigations)	8,619	2,685
Special Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla (Animal Health and Production Investigations)	9,792	5,973
Special Revenue Fund—Burdekin Bequest (Animal Health and Production Investigations)	2,389	..
Trust Fund Brown Rot Investigations—Brown Rot Survey (Plant Industry)	1,500	618
Commonwealth Bank and Other Contributor—Phytotron Development (Plant Industry)	20,000	20,000
Commonwealth Bank—Plant Breeding Investigations (Plant Industry)	633	633
General Donations (Plant Industry)	50	..
Western Australian Golf Association (Plant Industry Investigations)	50	..
River Murray Commission and Snowy Mountains Hydro-electric Authority—Alpine Ecology Investigations (Plant Industry)	3,281	3,750*
Australian Tobacco Research Trust (Tobacco Investigations)	92,612	91,568
Special Revenue Fund—Research Station, Mareeba (Tobacco Research Investigations)	2,195	..
Special Revenue Fund—Grazing Trials, Samford Farm (Plant Industry Investigations)	516	291
United Graziers' Association of Queensland and Australian Meat Board—Cattle Tick Investigations (Entomology)	1,000	..
United Graziers' Association of Queensland—Buffalo Fly and Cattle Tick Investigations (Entomology)	172	172
Australian Hide and Leather Industries Board (Cattle Tick and Leather Investigations)	2,087	2,087
General Donations (Division of Entomology)	32	32
Department of Primary Industry—Fruit Fly Investigations (Entomology)	11,000	9,002
Department of Supply (Soil Mechanics Investigations)	29,000	510
Country Roads Board, Victoria—King St. Bridge Investigations (Division of Soils)	250	1,236*
N.S.W. Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,000	2,000
Packing Companies and Co-operative Fruit Sales Ltd. (Dried Vine Fruits Investigations, Merbein)	1,000	956
Dried Fruits Control Board (Dried Fruits Investigations)	1,721	1,698
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	450	..
Special Revenue Fund—Research Station, Griffith (Citricultural Investigations)	24,613	10,545
Australian Meat Board (Meat Investigations)	119	368*
Metropolitan Meat Industry Board of New South Wales (Meat Investigations)	500	477
Queensland Meat Industry Board (Meat Investigations)	1,275	1,171
Department of Trade (Mutton Dehydration Investigations)	8,344	7,386
N.S.W. Department of Agriculture (Food Investigations)	1,099	1,000
Department of Primary Industry Fruit Fly Investigations (Food Investigations)	2,498	2,357
Apple and Pear Board (Food Investigations)	500	384
Various Contributors (Division of Food Preservation and Transport)	8,346	2,785
Australian Egg Board (Division of Food Preservation and Transport—Egg Investigations)	750	635
Commonwealth Can Makers' Association (Division of Food Preservation and Transport—Tinplate Investigations)	615	615
Department of Scientific and Industrial Research (U.K.)—Cooperative Meat Meat Investigations (Food Preservation and Transport)	242	242
N.S.W. Department of Agriculture—Quick Freezing of Fruit and Vegetables (Division of Food Preservation and Transport)	1,076	1,036
Paper Companies and New Zealand Forest Products (Paper Pulp Investigations)	5,168	4,097
Sundry Contributors (Forest Products Investigations)	8,132	1,872
General Donations—Pole Strength Research (Forest Products)	13,365	7,324
Department of Territories (Development of Pulp and Paper Industry in New Guinea)	3,366	3,304
Australian Plywood Board—Veneer, Gluing, and Plywood Research (Forest Products)	8,501	7,328
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	1,297	260
Territory Enterprises Pty. Ltd.—Tests on Base Metal Ore (Ore-dressing Investigations)	1,474	1,474
General Donations (Ore-dressing Investigations)	7,224	3,466

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* Expenditure on this work in excess of receipts will be recovered in 1958–59.

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	Receipts 1957-58 and balances brought forward from 1956-57.	Expenditure 1957-58.
	£	£
State Electricity Commission of Victoria—(Mineragraphic Investigations—Geological Consultations)	1,594	724
Miscellaneous Contributors (Mineragraphic Investigations)	116	..
Postmaster-General's Department (Radio Research)	15,000	14,212
Australian Broadcasting Control Board and Overseas Telecommunications Commission—Radio Research at Universities of Queensland and Adelaide	3,000	3,000
Miscellaneous Contributors (Division of Industrial Chemistry)	9,264	2,459
State Electricity Commission, Gas and Fuel Corporation, and Australian Paper Manufacturers Ltd.—Clinkering of Brown Coal Ash (Division of Industrial Chemistry)	3,000	1,516
Zircon Rutile Pty. Ltd., Australian Titan Products Pty. Ltd., Western Titanium N.L., and Associated Minerals Consolidated—Production of Rutile from Ilmenite (Industrial Chemistry)	7,877	8,964*
Mt. Morgan Ltd., Mt. Lyell Mining and Railway Co. Ltd., Mt. Isa Ltd., and Peko N.L. (Industrial Chemistry—Cooperative Investigations)	3,151	3,151
Mt. Morgan Ltd., Mt. Lyell Mining and Railway Co. Ltd., Mt. Isa Ltd., and Peko N.L.—Electrowinning of Copper (Industrial Chemistry)	7,420	5,855
Cement and Concrete Association of Australia—Cement Investigations (Industrial Chemistry)	5,563	3,426
Rio Tinto Pty. Ltd.—Water Evaporation Control (Industrial Chemistry)	2,122	1,953
Consolidated Zinc Pty. Ltd.—Resin-in-Pulp Project (Industrial Chemistry)	6,737	6,737
Smith, Kline, and French Laboratories, U.S.A.—Phytological Survey and Drug Plant Collection (Industrial Chemistry)	7,000	3,633
N.S.W. Government (Fisheries Investigations)	421	419
Department of the Navy—Marine Fouling Investigations (Division of Fisheries and Oceanography)	3,960	3,804
Department of Primary Industry—Pearl Shell Survey (Division of Fisheries and Oceanography)	2,249	2,181
Department of Primary Industry—Barracouta Investigations (Division of Fisheries and Oceanography)	200	50
Department of Supply—Examination of Gauges (Metrology)	2,343	1,547
General Donations (Division of Physics)	1,088	727
Miscellaneous Contributors (Mathematical Instruments Section)	126	..
Machinability Donations Account (Metrology)	350	..
General Donations (Electrotechnology)	300	229
General Donations (Tribophysics)	325	..
State Electricity Commission—Design and Use of Briquette Space Heaters (Building Research)	1,000	588
Associated Fibrous Plaster Manufacturers of Australia—Fibrous Plaster Research (Division of Building Research)	2,635	2,332
Paint Manufacturers' Association—Paint Research on Plaster Surfaces (Division of Building Research)	2,026	2,535*
General Donations (Division of Building Research)	1,720	..
Australian Wool Board—Biochemistry and General Nutrition Investigations (Sheep Research)	789	11
Various Contributors (Biochemistry and General Nutrition)	500	..
Snowy Mountains Hydro-electric Authority—Cloud Seeding Investigations (Division of Radiophysics)	6,429	3,651
Department of Civil Aviation—Radio Navigational Aids (Division of Radiophysics)	5,000	..
Committee for Dried Fruit Marketing (Division of Meteorological Physics)	12	..
Australian Dairy Produce Board—Cheese-making Project (Dairy Research)	3,804	3,804
Wool Buying and Selling Account (Wool Textile Research)	21,933	20,250
Wool Scourers, Carbonizers, and Fellmongers Federation of Australia (Wool Textile Research)	3,000	3,000
Shell (Chemical) Aust. Pty. Ltd.—Mothproofing Investigations (Wool Textile Research)	500	473
Patons and Baldwins Ltd.—Solvent Degreasing (Wool Textile Research)	1,250	1,230
Australian Wool Testing Authority—Wool Moisture Measurements (Wool Textile Research)	62	62
Associated Woollen Worsted Textile Manufacturers of Australia (Wool Textile Research)	2,032	..
Various Contributors (International Wool Textile Research Conference)	50	..
General Donations (Wool Textile Research)	32	..
Princeton Institute, U.S.A.—Princeton Wool Project (Wool Textile Research)	492	489
General Donations (Coal Investigations)	401	..
Bowen Consolidated Coal Mines Ltd.—Purchase of Infra-red Spectrophotometer (Coal Investigations)	3,750	3,750
Walter and Eliza Hall Institute—Duck Banding Investigations (Wildlife Section)	250	250
N.T. Administration—Goose Damage to Rice Crops (Wildlife Investigations)	4,724	4,705
I.C.I.A.N.Z. Ltd.—Duck Banding Investigations (Wildlife Investigations)	400	346
Department of National Development—Kimberley Research Station	365	1,874*
Department of Territories (Resources Survey—Papua-New Guinea)	19,556	19,226
Australian Meat Board—Pasture Development in Central Australia (Land Research and Regional Survey)	917	750
Commonwealth Bank (Genetics Investigations)	62	59
N.S.W. State Cancer Council—Cancer Research Project (Genetics Investigations)	422	267
General Donations (Genetics Investigations)	1,250	610
Sundry Contributors (Commonwealth Scientfiic and Industrial Research Organization—Publications)	24	..
Science and Industry Endowment Fund	2,591	2,305
Wheat Research Trust Account	2,000	1,777
	1,765,857	1,621,367

3. Wool Research Trust Fund Trust Account.

Details of transactions during 1957-58 are as follows:—

	£	£	£
Receipts 1957-58.			
Department of Primary Industry	..	..	1,289,100
Expenditure 1957-58.			
Investigations.			
Division of Animal Health and Production—			
Parkville Laboratory	6,451		
McMaster Laboratory	28,178		
Sheep Biology Laboratory, Prospect	180,418		
Regional Pastoral Laboratory, Armidale	69,448		
National Field Station, "Gilruth Plains"	34,218		
Sheep Breeding Investigations at McMaster Laboratory and McMaster Field Station	17,413		
		336,126	

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* Expenditure on this work in excess of receipts will be recovered in 1958–59.

* Expenditure on this work in excess of receipts will be recovered in 1958–59.

	£	£	£
Division of Plant Industry—			
Agrostology Investigations	132,247	132,247	
Research Services—			
Agricultural Research Liaison Section	9,820		
Wool Publications	720	10,540	
Division of Biochemistry and General Nutrition—			
Biochemical and Nutritional Investigations	42,180	42,180	
Wool Textile Research—			
Wool Textile Research Laboratories	340,362		
Division of Industrial Chemistry	33,020	373,382	
Wildlife Survey Section—			
Wildlife Survey	54,327	54,327	
Animal Genetics Section—			
Animal Genetics Investigations	28,778	28,778	
Miscellaneous—			
Overseas Studentships	3,127	3,127	
Total Investigations		980,707	
Special Item—			
Allocation for Establishment of Wool Buying and Selling Fund (Wool Textile Research)		17,800	
Total Investigations and Special Item			998,507
Capital Works and Special Items.			
C.S.I.R.O. Expenditure—			
Biological Research	14,512		
Wool Textile Research	27,034	41,546	
Department of Works Expenditure—			
Biological Research	160,810		
Wool Textile Research	40,038	200,848	
Special Items—			
Acquisition of "Mayfair"	24,527		
Silver Conversion Project	2,500	27,027	
Total Capital Works and Special Items			269,421
Total Expenditure			1,267,928
Balance carried forward to 1958-59			21,172
			1,289,100

During the year an amount of £95,854 was received from sales of sheep, wool, and other produce from C.S.I.R.O. Field Stations and Laboratories financed from wool funds. This amount was remitted to the Department of Primary Industry for credit to the Wool Research Trust Fund Trust Account.

4. Miscellaneous Receipts.

During 1957-58 miscellaneous receipts amounted to £152,501. Of this amount £16,315 represented proceeds of sales of equipment, publications, &c. The balance of £136,186 represented revenue earned by Divisions and Sections apart from the Special Revenue included under Section 2. Details of the receipts are as follows:—

General Revenue.

	£	£	£
Division of Animal Health and Production—			
Sale of Contagious Pleuropneumonia Vaccine	8,218		
Mastitis Investigations	1,426		
Parkville Laboratory	357		
Toxaemic Jaundice Investigations, Parkville, Victoria	304		
Oestrus Experiments	1,408		
Poultry Breeding Investigations	10,544		
Contagious Pleuropneumonia Investigations	1,736		
Bacteriological and Parasitological Investigations	196		
McMaster Field Station Revenue	2,382		
Veterinary Parasitology Laboratory, Yeerongpilly	66		
Cobram Field Station	202		
Division of Plant Industry—			
Plant Industry Investigations, Canberra	4,752		
Stanthorpe Field Station	546		
Plant and Soils Laboratory, Brisbane	25		
Division of Entomology	10		
Division of Soils—			
Merbein Research Station	7,118		
Soils Investigations	327		
Division of Food Preservation and Transport	286		
Division of Forest Products	181		
Ore-dressing Investigations	62		
Mineragraphic Investigations	50		
Research Services—			
Film Unit	79		
Engineering Section	57		
Division of Industrial Chemistry—			
Industrial Chemistry Investigations	31		
Microanalysis Investigations	4,457		
Division of Fisheries	80		
Division of Metrology	9,994		
Division of Electrotechnology	902		
Division of Physics	2,250		
Division of Building Research	131		
Division of Radiophysics	67		
Meteorological Physics Section	6		
Wildlife Survey Section	182		
Land Research and Regional Survey, Katherine	35		
Coal Research Section	230	58,697	
Royalty Receipts—			
Division of Industrial Chemistry	77,415		
Division of Food Preservation and Transport	20		
Research Services—Film Unit	49		
Division of Metrology	5	77,489	
Other Receipts—			
Sales of publications	4,380		
Sales of equipment, &c.	11,935	16,315	
			152,501

The above sum was paid to the credit of the Trust Fund, Science and Industry Account during 1957-58 and consequently reduced the requirements from Treasury sources by that amount (see Section 1).

5. Works Projects (under Control of C.S.I.R.O.).

Treasury expenditure on works projects financed from funds made available directly to C.S.I.R.O. is as follows:—

	£	£	£
Plant Industry—			
Canberra Experiment Section—			
Developmental expenditure	1,728		
Development of Phytotron	8,001		
Samford Farm—			
Creek crossings, fencing, and clearing	729		
Plant Introduction Station, Kelmscott—			
Miscellaneous	295	10,753	
Entomology—			
Cattle Tick Investigations, Townsville—			
Fencing	249	249	
Food Preservation and Transport—			
Meat Research Laboratory, Cannon Hill—			
Cold room	1,203		
Food Processing Laboratory, Hobart—			
Boiler for processing plant	1,808	3,011	
Fisheries and Oceanography—			
Fisheries Laboratory, Cronulla—			
Connexion of gas	640	640	
Meteorological Physics—			
Aspendale Laboratory—			
Site development	66		
Electrical outlets	156		
Weighing equipment	2,799		
Miscellaneous	246		
Power line	716	3,983	
Radiophysics—			
Rainmaking Investigations—			
Purchase of aircraft	71,000	71,000	
Treasury Expenditure			89,636

6. MISCELLANEOUS SERVICES.

	£
Contribution to Commonwealth Agricultural Bureaux	49,711
Grant to Standards Association of Australia	50,000
Contribution to Chair of Aeronautics at University of Sydney (establishment and maintenance)	5,000
Grant to National Association of Testing Authorities	11,400
National Institute of Oceanography	6,269
Minor International Associations	1,275
	123,655

XXXVI. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made as in previous years to the valuable assistance afforded by many State Departments, universities, and other organizations and individuals. The Organization desires to express its gratitude for the help given by these bodies and persons in providing laboratory accommodation and other facilities and in many other ways. The Organization also wishes to acknowledge the assistance which it has received from its Committees, the members of which have placed their knowledge and experience so freely at its disposal.

I. CLUNIES ROSS, Chairman
F. W. G. WHITE
S. H. BASTOW
A. W. COLES
J. MELVILLE
} Executive.

18th September, 1958.

Printed and Published for the GOVERNMENT of the COMMONWEALTH OF AUSTRALIA by
A. J. ARTHUR, Commonwealth Government Printer, Canberra.